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THE

# TRANSACTIONS

OF THE

# MICROSCOPICAL SOCIETY

OF

# LONDON.

VOL. III.

1852

"MINIMIS PARTIBUS, PER TOTUM NATURÆ CAMPUM, CERTITUDO OMNIS INNITITUR; QUAS QUI FUGIT, PARITER NATURAM FUGIT."—*Linnæus.*

LONDON:

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# TRANSACTIONS

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VOLUME III.

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I.—*Observations on the Nature of Capillaries, and on the mode of arrangement of those in the Gills of Fishes.* By JOHN QUEKETT, Esq., Assistant Conservator of the Museum, and Demonstrator of Histology at the Royal College of Surgeons of England.

(Read May 19th, 1847.)

FROM the time of De Graaf, Ruysch, Lieberkuhn and other celebrated anatomists, the art of injecting the minute blood-vessels of animals and of the human subject with mercury, and with coloured fluids by means of a syringe, has been much practised both in this country and abroad, and the science of Anatomy has been wonderfully advanced by its use.

The first anatomist who appears to have applied the syringe to the filling of the blood-vessels was Regnerus de Graaf, a Doctor of Medicine, who lived about the middle of the seventeenth century; an engraving and full description of the syringe used by him was published in the year 1667, in a small treatise, entitled 'Tractatulus de usu Syphonis in Anatomia.' Some authors claim the credit of the invention for Swammerdam, who is said to have first employed it in 1667. The fluids used by De Graaf were by him termed tinctures, and were coloured with copper, or with the juices of the leaves of violets or roses, or a solution of gamboge and indigo. He does not state whether the vessels so filled were dried and preserved, the chief object he desired being to trace more readily the different ramifica-

tions of the vessels. Since the time of De Graaf, however, various other substances have been used, and amongst the chief of these may be mentioned, injections of wax, tallow, varnish and size, with some colouring agent diffused through them; these are injected whilst hot, and when allowed to cool become so firm, that, with the exception of those of size, the individual vessels may be dissected away from the various tissues and organs to which they are distributed, and when perfectly dried and well varnished such preparations will keep for many years. From the circumstance of wax, tallow, and varnish requiring a high temperature to keep them fluid, unless the temperature of the part injected be also very high, at least above the melting point of the materials used, the fluid injected will not run into the most minute vessels, hence none but those easily discernible by the naked eye will be filled; this has been found inconvenient, and other fluids, such as size and isinglass, which melt at a very low temperature, and get solid on cooling, have been substituted; these will fill other vessels so minute that the microscope is required to discover their wonderful ramifications; and of all the important discoveries made by means of the microscope, perhaps the nature of the capillaries, and the capillary circulation, are the most highly to be esteemed, for it is to this instrument that we owe the proof of the correctness of the doctrine taught by the immortal Harvey, that the blood really circulates in the arteries and veins; though Harvey himself never witnessed the circulation, he argued, from the structure and arrangement of the valves in the heart and in the veins, that the blood must flow from the heart through the arteries to the veins, and from the veins back to the heart again, yet he knew nothing of the connecting vessels or capillaries. We are indebted for all that is now known of them to the microscope, and to the art of injection. It was left for Malpighi to make the discovery of the capillary circulation, and he, we are told, first noticed it in 1661, by the microscopic examination of the distended urinary, or allantoid bladder of a frog. Since then, the discovery of Malpighi has been confirmed by numerous other observers. Anatomists have been led to divide injections into the coarse and the fine, the coarse being used when the mode of distribution of the large arteries and veins is required for examination, the fine when an intermediate system of vessels between or connecting the arteries and veins, termed capillaries, is to be investigated; the coarse injections are sufficient for the unassisted sight, the fine for microscopic investigation. Lieberkuhn appears to have been the first to apply the microscope to injections. Many of

the injections of this celebrated man are still extant, and a few microscopists in this country are fortunate possessors of some of his beautiful preparations.

The older anatomists, we are told,* with Haller at their head, adopted a notion that arteries terminated in one of five ways: 1st, by openings on the surface of membranes; 2nd, in lymphatics; 3rd, in secreting canals; 4th, in fat; 5th, in veins. In those times the secretion of mucus and fat could not be understood, without presupposing the existence of open extremities. This view of the subject was strongly opposed by Mascagni, Prochaska, Sœmmering, Hunter and others, but there still remained a doubt whether there were not some communication between the blood-vessels and the secreting canals of the glands. In more modern times, the structure of the secreting glands has been studied by Müller and other physiologists in process of development in the embryo, and the secreting canals of the glands have also been injected, and no such communications have been found to exist, the radicles of the secreting canals being always closed at their radicle extremity.

Anatomists now, with one consent, agree that in all organic textures, the transmission of the blood from the minute branches of the arteries to the minute veins, is generally effected by the capillary net-work, between the meshes of which the proper substance of the organ lies; this structure is commonly termed parenchyma, and speaking of it as a tissue, it is termed parenchymatous tissue; thus, for instance, in a specimen of injected lung or kidney, or in a villus from the intestine, the parts not occupied by blood-vessels constitute the true parenchymatous tissue of the organ. All microscopists are familiar with the circulation in the foot of the frog, and the tail of the newt; this is, for the most part, the capillary circulation. The ramifications of the minute arteries form repeated anastomoses with each other, and these anastomoses terminate at last in a continuous net-work, from which the small branches of the veins take their rise. The point at which the arteries terminate and the minute veins commence, cannot be exactly defined; the transition is gradual, but the intermediate net-work is so far peculiar, that the small vessels which compose it maintain nearly the same size throughout; they do not diminish in diameter in one direction, like arteries and veins, hence the term capillary, from *capillus*, a hair.

The size of the capillaries is proportioned in all animals to that

* Müller's Physiology, translated by Baly, vol. i. p. 227.

of the blood corpuscles; thus amongst the *Reptilia*, where the blood-corpuscles are the largest, the capillaries are also the largest, but it does not follow that they should be always of the same size in all the tissues of one and the same animal, for if we examine and carefully measure in the human subject their sizes in different tissues, we shall find that they vary greatly even in individual tissues, and at a rough estimate, examples may occur as large as a thousandth, whilst others are as small as the four-thousandth or five-thousandth of an inch. They should be measured if possible in their natural state; when injected, their size is slightly increased, but when dried they diminish so considerably, that in some specimens vessels imperfectly filled with injection have been known to shrink from the three-thousandth to the twenty-thousandth of an inch.

In fœtal animals, having the blood corpuscles larger than those in the adult state, the capillaries also are larger.

Capillaries are, with very few exceptions, always supported by an areolar net-work, which serves not only as an investment to them, but connects them intimately with the tissues they are destined to supply.

Having said thus much of the nature of the capillaries, we will now proceed to consider those points which are the more immediate objects of this paper; *viz.*, the distribution of the capillary system in the respiratory organs of Fishes.

In the majority of osseous fishes there are four gills on each side, supported by long curved branchial arches. Each gill consists either of a single or a double series of lancet-shaped laminæ attached to the branchial arch, something like the teeth to the back of a comb. When there is only one series of laminæ, the gill is termed *uniserial*, but when two, *biserial*. The branchial arches in osseous fishes are more or less bony, and from the lower convex surface are given off in uniserial gills one, in biserial two, elastic, more or less round filaments, which form the outer support or framework of the laminæ; and if the mucous membrane and all the soft parts be removed, it will be found that in many fishes a series of more minute filaments are given off at right-angles from the inner side of the larger one, each of these smaller filaments serving not only to support the laminæ, but each one performing the same office to the outer margin of the folds of mucous membrane on the laminæ, as the larger filament does to the lamina itself; this skeleton of the lamina resembles in every respect a small comb. Upon this framework we have a fibrous or areolar tissue, which not only invests the little teeth, but

fills up all the interspaces between them, and over this are situated the plicæ or transverse folds of the respiratory mucous membrane, which, in some of the large fishes are upwards of a thousand in number, the outer margin of each fold, as before stated, being supported by a process of the outer filament of the lamina. In Plate I. fig. 1, is shown one of the laminæ from the eel, and in fig. 1 *a*, are seen both the outer filament, and the plicæ of the mucous membrane, each supported by a process from the large filament. The filaments have by some authors been described as bony, but even in the salmon and eel they contain no ossific matter, being composed of a cellular structure, somewhat of the nature of cartilage or newly-developed horn; the outer margin is made up of small circular cells arranged in rows at right angles to the length of the filaments, whilst on the inner surface the cells are of an elongated oval figure, and arranged in lines parallel to the length of the filament.

The arteries termed branchial, which bring the impure blood to the gills, run along the convex border of the branchial arch, and opposite each pair of laminæ, divide into two or more branches, which run along the outer thick margin of the lamina to its extremity, and in their course give off two transverse branches, one for every fold of mucous membrane of the two flat or opposed surfaces of the laminæ; in these folds the artery breaks up into a net-work of most wonderfully minute capillaries; the branchial vein begins in these capillaries, and the entire series unite into transverse branches, from which large venous trunks are formed: these run along the inner or attached edges of the laminæ, as shown in Plate I. figs. 3 and 3 *a*, there being branchial arteries on one margin and branchial veins on the other, and between the two the net-work of capillaries shown in figs. 1 *a*, 2 *a*, &c.

The osseous fishes in which the gills have been more particularly examined, are the salmon, wolf-fish (*Anarrhicus*) and eel, of the latter the river eel requires special mention. Three of the lancet-shaped lamellæ of this fish are represented in different positions in Plate I. figs 1, 2, 3, as seen under a magnifying power of twenty diameters; portions of the same magnified a hundred diameters, are represented at figs. 1 *a*, 2 *a*, 3 *a*; the first three figures serve to show the lateral lamellæ and plications of the mucous membrane, whilst the last three exhibit very plainly the beautiful net-work of the pulmonary capillaries, distributed upon it; these are of nearly uniform size ($\frac{1}{1000}$) in diameter, and the interspaces of the net-work much smaller than the diameter of the capillaries themselves, but still so cha-

racteristic of a respiratory mucous membrane, that a practised eye would immediately discern their true office.

In the cartilaginous fishes, the arrangement of the gills presents many varieties; those only to be described here occur in the rays and lampreys; in the former, the branchial arches are composed of soft cartilage, and do not hang loose in the branchial chamber as in most osseous fishes, but are attached by both extremities, so that the chamber is divided into five compartments distinct from each other, each having an orifice on the external surface of the body. The branchial lamellæ are given off from the arches in the form of folds, parallel to each other and continuous with the mucous membrane; in the first four cavities there are two gills, one on the anterior and the other on the posterior surface of the arch, but in the last cavity there is only one gill, and that on the anterior part of the arch.

In the lampreys there are no branchial arches, but seven branchial cavities or pouches, perfectly distinct from each other, each of which has two openings, one communicating with the pharynx, and the other situated on the external surface of the body; the interior of each chamber is lined with the branchial mucous membrane, which is plicated transversely, in the same way as it is on the laminæ of the osseous fishes, and each fold has its characteristic net-work of capillaries. In the river lamprey (*Petromyzon fluviatilis*), the capillaries are quite as small, if not smaller, than in an eel of the same size, but it is in *P. marinus*, and more especially in the rays, that the most largely developed net-work is found; in these latter, the blood corpuscles are also of larger size than in other fishes. Portions of one of the laminæ from *P. marinus* are represented as seen under a power of twenty diameters, at fig. 4, and under that of fifty at fig. 4 *a*, and similar specimens from the ray, in figs. 5 and 5 *a*; these, although only magnified to one-half of the extent of those of the eel, exhibit the capillaries, nevertheless, much more plainly.

Of all the fish in which I have been able to inject the capillary plexus satisfactorily, the eel exhibits the smallest vessels; in an eel about twelve inches in length, the laminæ were on an average not much more than one-quarter of an inch long, and on each lamina I was able to count upwards of eighty plicæ, each having a plexus of capillaries so minute, that a good defining power of fifty diameters was required to make them out, and one of a hundred diameters to show them satisfactorily, the diameter of a single capillary being the four-thousandth of an inch, so that it becomes a question whether vessels so small as these were ever seen by the early microscopists.

In the rays and lampreys, the capillaries being so very much larger, $\frac{1}{1100}$ in diameter on an average, can of course be more readily distinguished, but even these require a good microscope for their due exhibition; which may account in a great measure for the silence, on this point of anatomy, of all the authors whom I have consulted on the subject of the circulation in the respiratory organs of fishes. To fill up a certain portion of this hiatus, and to show how wonderfully minute are these capillaries, and yet in their arrangement so characteristic of the vessels performing a similar office in the higher orders of animals, this paper has been brought before the Society on the present occasion.

## EXPLANATION OF PLATE I.

Fig. 1. A branchial lamina of a common eel, showing the concave edge along which the branchial vein runs, and the small transverse plicæ or folds of the mucous membrane.

Fig. 1 *a*. A portion of the same more highly magnified, to show the capillary plexus upon the fold of the mucous membrane.

Fig. 2. One of the laminæ of the common eel, showing the folds of mucous membrane given off from both sides of the lamina.

Fig. 2 *a*. A portion of the same magnified one hundred diameters.

Fig. 3. One of the laminæ of a common eel, showing the convex border on which the branchial artery, and the concave one on which the branchial vein runs, and the folds of mucous membrane between them.

Fig. 3 *a*. A portion of the same magnified one hundred diameters.

Fig. 4. A portion of one of the laminæ of a lamprey (*Petromyzon marinus*), showing the broad transverse folds of the mucous membrane.

Fig. 4 *a*. A portion of the same magnified fifty diameters, to show the capillary plexus on the folds.

Fig. 5. A portion of one of the laminæ of a ray (*Raia batis*), showing the folds of the mucous membrane.

Fig. 5 *a*. A portion of the same magnified fifty diameters; it shows the large size of the capillaries composing the plexus.

Fig.1.

Fig.2.

20 dias

Fig.3.

Fig.1 a. 100 dias

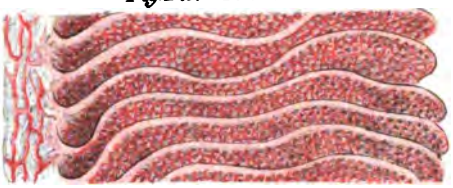


Fig.2.a. 100 dias

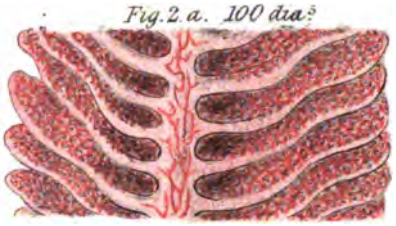


Fig.3 a. 100 dias

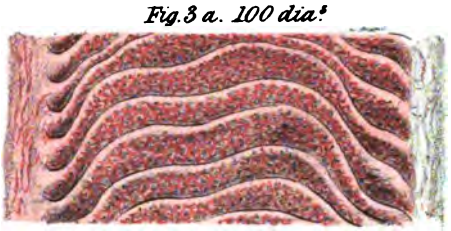


Fig. 4. 20 dias

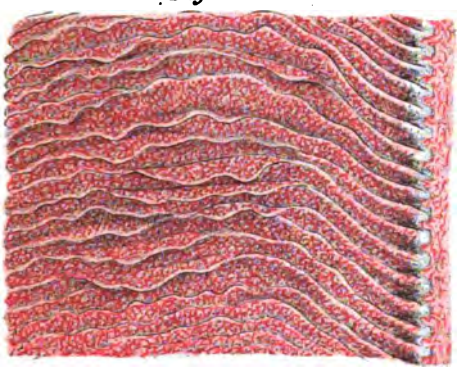


Fig.5. 50 dias

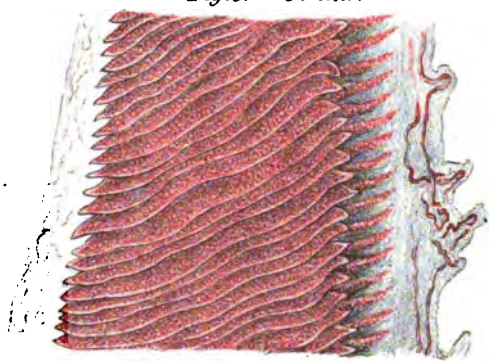


Fig. 4.a. 50 dias

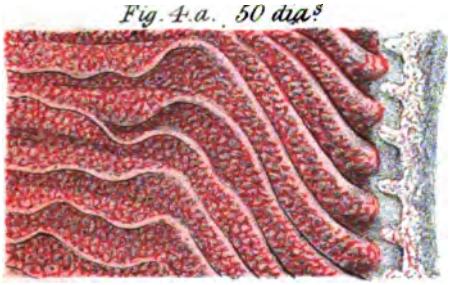
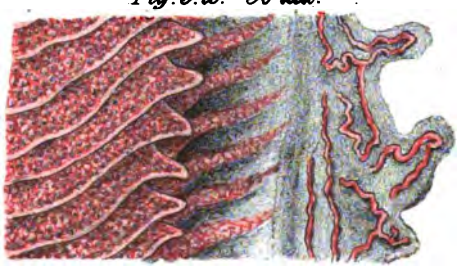


Fig.5.a. 50 dias



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## II.—*Observations on the Vascularity of the Capsule of the Crystalline Lens, especially that of certain Reptilia.* By JOHN QUEKETT, Esq., Assistant Conservator of the Museum, and Demonstrator of Minute Anatomy at the Royal College of Surgeons of England.

(Read January 13th, 1847.)

THERE are certain tissues in vertebrate animals that have been termed non-vascular, that is, tissues in which in the healthy state no vessels carrying red blood have hitherto been discovered; amongst these are classed, by most observers, the cornea, the capsule of the crystalline lens, and the vitreous humour or body. Before the adoption of the theory of nutrition and growth by the agency of cells, the existence of vessels far too minute to carry red blood, but which allowed lymph and serum to traverse them (hence called *vasa serosa*) was inferred, but as yet such vessels have never been satisfactorily demonstrated.

Many mistakes have arisen from the circumstance of certain of these tissues having been examined at one time in the growing state, at another when diseased, in both of which cases, blood-vessels are not unfrequently present, but in the adult and perfectly healthy state, such tissues have no vessels in their interior, but in their immediate neighbourhood only. We have examples of this kind in articular cartilage, which in the growing state is vascular and nourished by synovial membrane; in the cornea again, the vessels are supplied from the conjunctiva, as has been admirably shown by Mr. Toynbee. It is now, however, well known, from the researches of Schleiden and Schwann, that all tissues are developed from cells, and the researches of Mr. Toynbee go to show that as long as the true cell-form remains, these structures require vessels in their neighbourhood only.

If we examine an injected eye of a young animal, we shall find (if the injection have been successfully performed) that the posterior layer of the capsule of the lens, is largely supplied with blood-vessels, derived from an artery running through the vitreous humour, and called the *arteria centralis retinæ*. If, however, the animal be an adult, the capsule can rarely, if ever, be injected; this holds good in the human subject and in *Mammalia* generally, but one of the prin-

cipal objects of the present communication is to point out, that in some of the *Reptilia*, namely, the frog, toad, boa and common English snake, the posterior layer of the capsule of the lens is capable of being injected in animals of all ages.

In these reptiles, it is worthy of notice, that the crystalline lens is of a spherical shape and of large size as compared with the chambers of the eye in which it is enclosed.

In the boa (*Python tigris*) as shown in Plate II. fig. 1, the capillaries of the posterior layer of the capsule are injected, and instead of there being only one or two vessels passing through the vitreous humour to supply it, there are four, the two smallest, in all probability being arteries, and the other two of larger size, veins; the capsule it will be seen does not extend much farther over than half the surface, or what may be termed the equator of the lens, and appears to be very loosely attached to it, the free margin projecting some little distance from its surface. The capillary net-work is very delicate, and in arrangement is quite different to that found in the eyes of fœtal mammalian animals.

In the common English snake (*Coluber natrix*) the vessels of the capsule are small and very numerous, and the capsule itself extends a little beyond the equator of the lens, its free margin being formed by a large vessel, probably a vein, which surrounds nearly the whole circumference of the capsule and terminates in one of the vessels of the iris; the vessels of the capsule, when removed and laid flat, very much resemble a basket: in this animal there appears to be only one vessel, probably an artery to supply the capsule.

In the frog and toad, the same arrangement of parts is to be seen, except that in both these animals, especially in the toad, the vessels of the capsule are much fewer in number, and very much larger in diameter, than in the two preceding specimens; the large vein surrounding the free margin of the capsule is present in both, and if the lens be removed from the choroid, the large vessel must be divided before it can be separated from the iris; in fact, the strength of this vessel is such, that if the iris be held up by a pair of forceps, the lens will be found suspended from it.

Before quitting the subject of the vascularity of the posterior layer of the capsule of the lens, it will be as well to point out in this place another peculiarity which I have observed in the boa and snake, *viz.* the vascularity of the thin transparent layer of skin covering the eye of these animals. A specimen of this kind from the boa, is represented in Plate II. fig. 2; the vessels are of large size, and their mode

of arrangement visible even to the naked eye, they are found to be connected with those on the inner layer of the skin. The presence of these vessels is very remarkable, and serves to show that the sense of vision of such animals must be far from perfect, for the rays of light entering the eye must necessarily pass, first through these vessels of the skin, and then those of the posterior layer of the capsule, before they can fall upon the retina. It might be asked whether such vessels exist in the Batrachian reptiles; as far as my experience goes, I have never yet been able to trace them.

In the mammalian fœtus, the vessels of the posterior layer of the capsule are readily injected, but in the adult eye, except in cases of disease, I have hitherto failed to fill them; in the fœtus, however, they are of small size and very numerous, and in these animals we may with ease often find that the anterior layer of the capsule is injected as well as that of the posterior, and if the lens be removed entire, it will be seen that the whole of its outer surface is covered with vessels, but, as will presently be shown, the vessels of the two layers differ materially both in size and arrangement. The vessels of the posterior layer of the capsule of the fœtal wolf, as shown in Plate III. fig. 1, are of small size, they are derived from the *arteria centralis retinæ*, which after reaching the capsule divides generally into two branches, each of which divides and subdivides in a radiating manner, so as to form a delicate plexus; on reaching the equator of the lens, the vessels become more or less straight, and in some cases, each straight vessel will split up into two branches, one of which will pass into or join the vessels of the anterior layer of the capsule, and the other anastomose with those of the iris.* The vessels of the anterior layer, as shown in Plate III. fig. 2, are of much larger size and less numerous than those seen in fig. 1, which is a representation of the posterior layer of the same lens, and they evidently correspond in arrangement to those described as peculiar to the *membrana pupillaris*, and as I have never been able to find two sets of vessels in front of the capsule, it would appear that the presence of a *membrana pupillaris;* as generally described as filling up or closing the aperture of the pupil, is more or less the result of accident: if the lens come away with its capsule entirely covered with vessels, no *membrana pupillaris* will be found; but if (as frequently happens) the straight vessels above described as passing into the an-

* Examples of the anastomosis of the vessels of both layers of the capsule, will be seen in all the figures in Plates III. and IV.

terior capsule give way, then the layer of the capsule may be retained by the vessels connecting it with the iris, and so form the *membrana pupillaris*. If a perfect specimen of *membrana pupillaris*, as shown in Plate IV. fig. 1, be examined *in situ*, some of the vessels that connected it with the posterior layer of the capsule, will be found lying loose around the margin of the iris. It will be seen also from the representation of the vessels of the anterior layer of the capsule of the fœtal wolf, in Plate III. fig. 2, and of the kitten, in Plate IV. fig. 1, and of a fœtal dog, in fig. 2, that the arrangement is not the same in different animals; the vessels of the human fœtus are different from any of these, but most nearly resemble those of the kitten in Plate IV. fig. 1. From what I understand of the structure of the *membrana capsulo pupillaris* of Henlé, and from his description and representations of the vessels, the parts above described as coating the lens, must be considered as identical with his so-called *membrana capsulo pupillaris*; but he does not appear to be aware of the fact, that the anterior layer when separated from the posterior, goes to form the *membrana pupillaris* of the older anatomists.*

The fact of the permanent vascularity of the posterior layer of the capsule of the lens of *Reptilia*, as far as I can learn, is new to science, and for this reason I have been induced to bring it before the Society, and at the same time to introduce a new method of printing blood-vessels in colour; the drawings in illustration of this subject now exhibited, having been first made by Mr. Aldous, and subsequently printed by an improved process of Mr. Hulmandel.

* Since this paper was read, my attention has been directed to the description of an injected capsule of the lens of a young rabbit, in the Catalogue of the Museum of St. Thomas's Hospital; and I am happy to find that the opinion both of Mr. Grainger and Mr. Rainey coincides with my own, *viz.*, that the anterior layer of the capsule and the *membrana pupillaris* are identical.

Pl. IV.

*Fig 1.*

*Mag^d 20 dia^s*

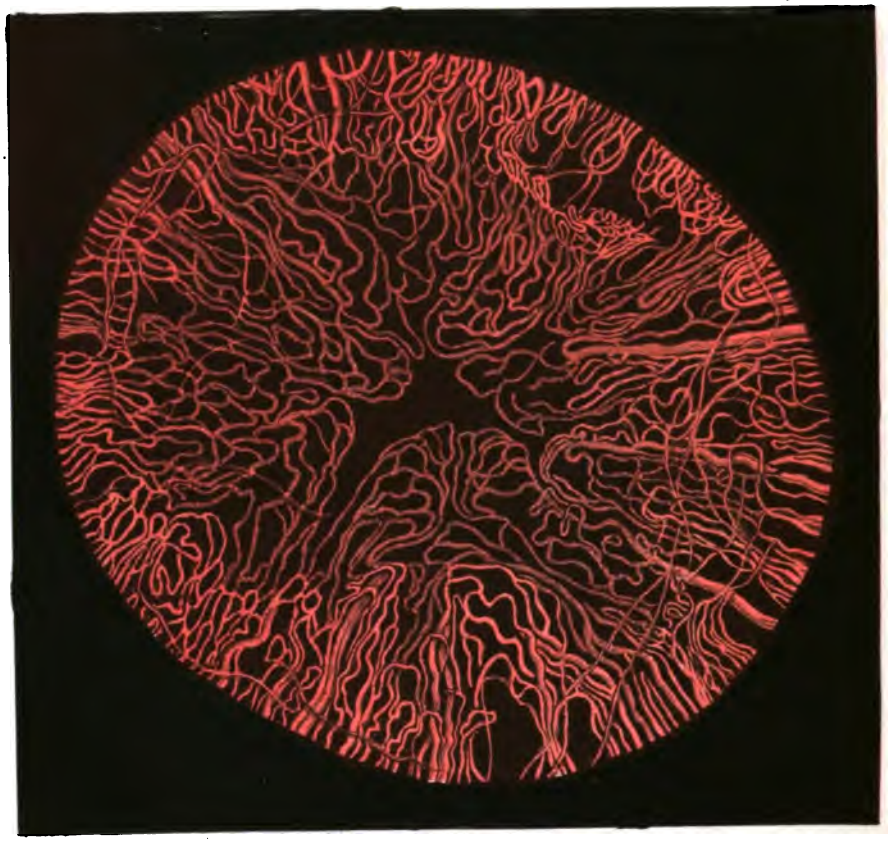
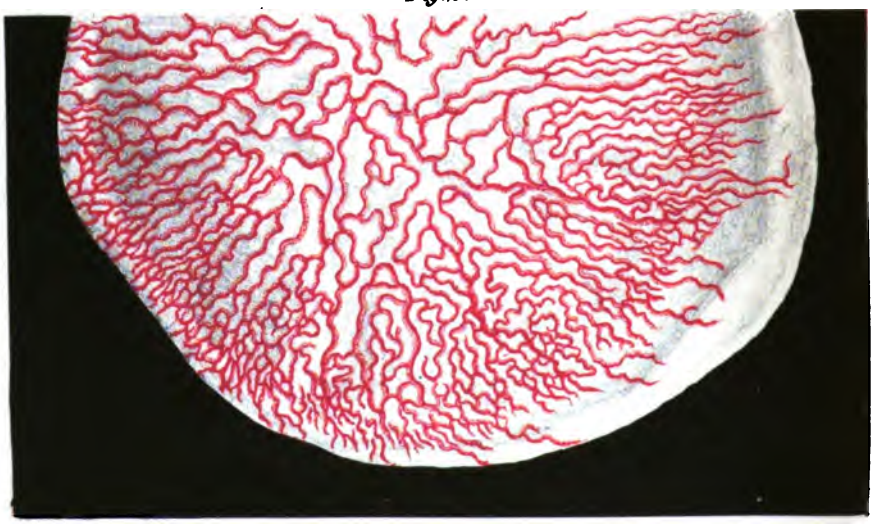


*Fig. 2.*



*S.W Leonard. del et lith.*

*Day & Son, Lith^rs to The Queen.*

*Fig. 1.* *Mag.d 20 diam.s*

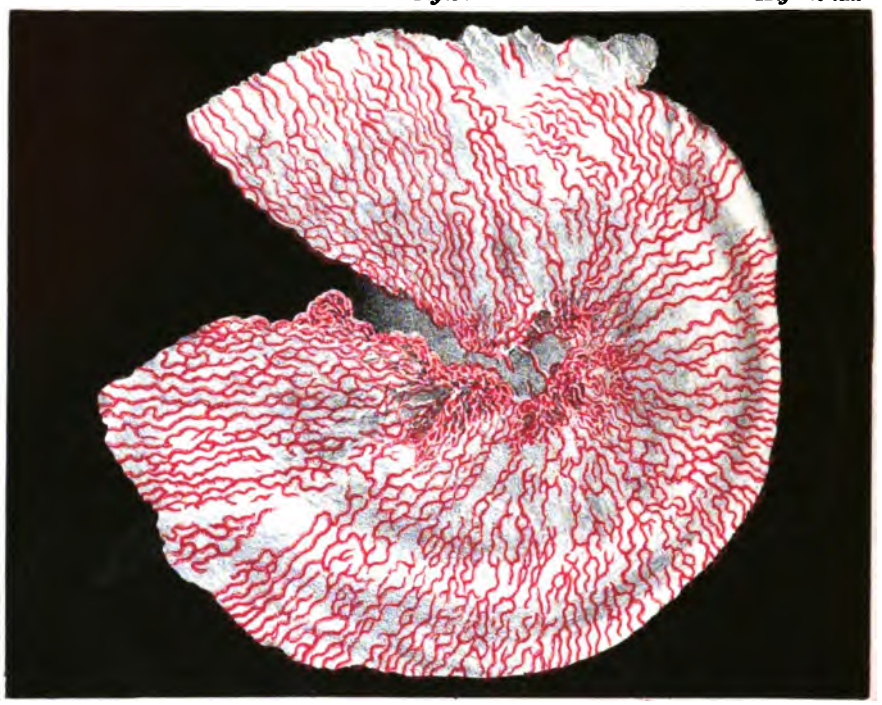
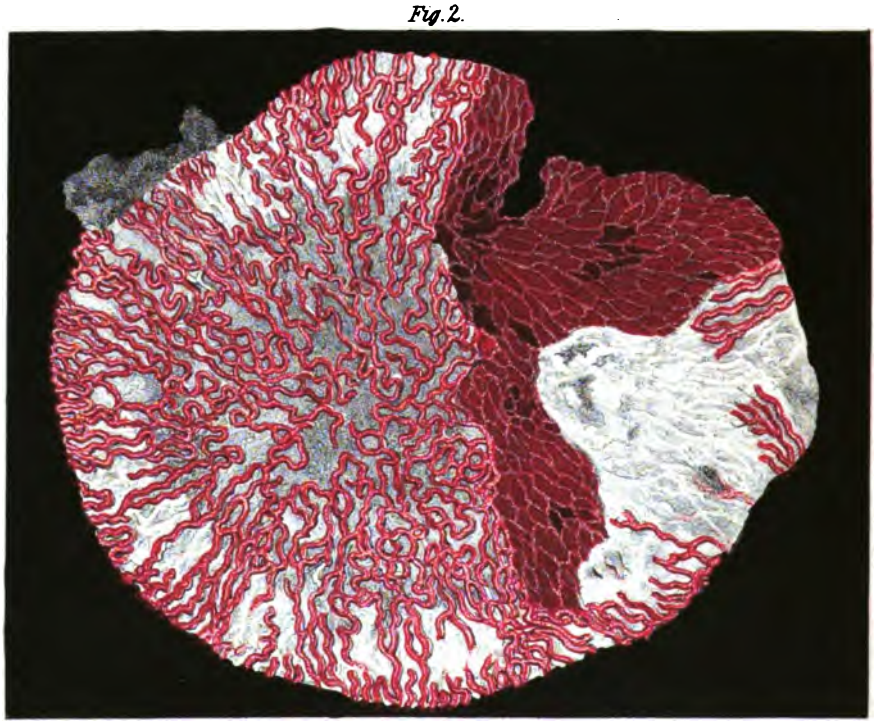


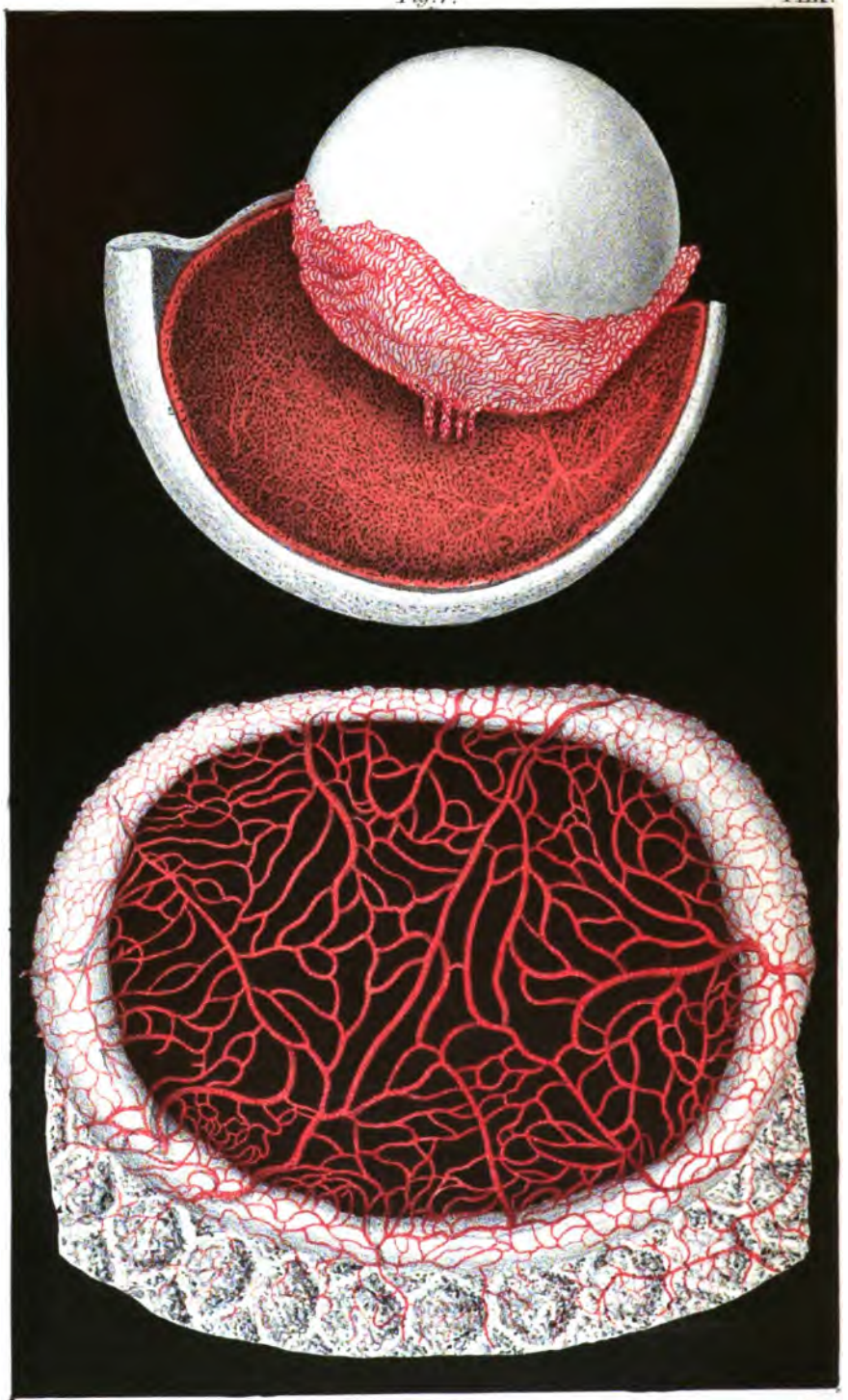
*Fig. 2.*



S. W. Leonard, del. et lith

Day & Son Lith.rs to The Queen.

Fig. 1. PL. II.



S.W. Leonard, lith. Fig. 2. Day & Son lith to The Queen

## EXPLANATION OF PLATES II. III. IV.

Plate II. fig. 1. Portion of the sclerotic and choroid coats of the eye of the tiger boa (*Python tigris*) to which are attached the crystalline lens with its capsule injected.

fig. 2. The thin layer of skin covering the conjunctiva of the same boa, with its blood-vessels injected.

Plate III. fig. 1. Vessels of the posterior layer of the capsule of the lens of a fœtal wolf.

fig. 2. Vessels of the anterior layer of the capsule of the same lens.

Plate IV. fig. 1. Vessels of the anterior layer of the capsule of the lens of a kitten, these form the *membrana pupillaris*.

fig. 2. Vessels of the anterior layer of the capsule of the lens of a fœtal dog.

In each of the four last figures the anastomosis of the vessels of the anterior and posterior layer of the capsule is well represented.

## III.—*Observations on some part of the Anatomy of two species of Naked-eyed Medusæ.* By George Busk, Esq., F.L.S., President of the Society.

(Read October 25th, 1848.)

Indispensable as the use of the microscope must, at the present day, be considered in the study of the minute structure of all organized beings, there are, perhaps, none so obviously the proper subjects of microscopical research, as those constituting the extensive class of the *Acalephæ* or jelly-fishes. The pellucid transparency of the tissues of most of these creatures, and the extreme minuteness also of many of them, absolutely require that the eye should be aided, to enable us to arrive at any satisfactory result in their examination. At the same time the beauty and variety of form and colour presented in this class of animals, their abundance, and the facility with which many species may be procured, would appear to offer the greatest temptation, even to those who employ the microscope merely as an instrument of rational amusement. But to the scientific inquirer, the study of the structure of these creatures presents a highly interesting and important field. The still obscure relations of this class with regard to the rest of the invertebrate kingdom, the interesting physiological considerations involved in their modes of development, and the favourable conditions afforded by the peculiar delicacy and transparency of their tissues, for the studying, as it were, of the ultimate elements of the animal structure, all would seem to demand, and to be, above all things, likely to reward the closest investigation. Until lately, however, the microscopical study of these animals does not appear to have been much attended to, or at all events, not to have been very successfully pursued. All that is trustworthy or useful in this respect has been afforded by Milne-Edwards, R. Wagner, Will, Kölliker and our eminent countryman Prof. E. Forbes. To the beautiful monograph on the naked-eyed *Medusæ* by the last-named author, recently published under the auspices of the Ray Society, I would refer you for the fullest information as to the present state of knowledge respecting the animals of which it treats. I will here merely premise, that in that work, the extensive class of pulmograde *Medusæ* is subdivided into two groups, characterized

respectively by the presence or absence of protective appendages to the ocelli, or what are considered as such; and as this distinctive character also appears to imply important differences in other respects in the structure of the animals, it is to be regarded as of the highest utility. Prof. Forbes's monograph embraces those pulmograde *Medusæ* which have no protective appendages to the ocelli, and are from that circumstance termed "naked-eyed," or the *Gymnophthalmata*. It is to two species only of this family that the following observations refer. These two species belong to two genera differing very widely from each other, and of which one may be regarded as representing the highest form of development in this class of *Medusæ*, and the other, perhaps, the lowest or most simple. The species which opportunity rather than choice has caused me to select for observation, are *Turris neglecta* and a species of *Thaumantias*, which I am unable to name with certainty. Both species, with numerous others, occurred abundantly in the sea around the northern and eastern shores of the Isle of Wight, and also in Portsmouth Harbour; and the observations were made in the month of September last (1848).

In Prof. E. Forbes's work the genus *Turris* is thus defined:—"Umbrella subcylindrical or mitrate; ovaries four, double, dense, convoluted, lining the cavity of the peduncle; vessels simple; margin of the umbrella with numerous tentacula; muscles of the disk conspicuous and highly developed; mouth of the peduncle fimbriated." And the species *T. neglecta* as follows:—"The umbrella transparent, smooth, and subhemispheric, inclining to conical; summit slightly pointed; subumbrella reaching to little more than half the height of the former, slightly pyramidal with a truncated summit; the muscular bands are distinctly seen striping its sides; peduncle large, of a substantial aspect, in consequence of the compact masses of rich crimson or vermilion convoluted and fimbriated ovaries which occupy its broader and upper half: the peduncle terminates in four lips, fimbriated at their edges and highly muscular; radiating vessels four, simple; marginal tentacles close set, more than sixty in number ($16 \times 4 + 4$), very contractile, being sometimes elongated into hair-like filaments, and at others contracted into little knobs; each tentacle has a large bulbous base, the upper part of which bears a brilliant ocellus, consisting of crimson pigment-cells, and there is another speck, probably the site of an otolitic mass below." Coloured figures also of the animal and of certain portions of its anatomy magnified, are given in Plate III. of the same work. As my own observations with respect to some of the anatomical and structural

details, differ in their result to a certain extent from those of Prof. Forbes, it is to those portions that I am desirous, in the following remarks, more particularly of directing your attention.

This *Medusa* is not so perfectly transparent as many of its congeners, and its texture is more solid and firm to the feel than it is in many others. It is very active and vigorous in its movements, and may be kept alive some time with a little care. Some idea of its form and appearance may be derived from fig. 1 *a*, and magnified fig. 1 *b*. Few objects can be conceived more elegant and graceful in form and colour than the tiny, ruby-tinted *Turris neglecta*, gently rising and sinking, or suspended in its native element; its long filamentous tentacles, extended to their full length, waving about and surrounding the creature as it were with a delicate halo. The disk of all these *Medusæ* appears to be composed of two distinct membranes or layers, of which the external is termed the umbrella, and the internal or inferior, the subumbrella. To the margin of the disk are appended the tentacles, and in some cases other organs, about which more will be said in the subsequent observations upon the *Thaumantias*. From the centre of the subumbrella in most genera, depends, like the clapper of a bell, the peduncle, which contains the stomach or digestive cavity, and in some genera also supports the ovaries or reproductive glands. Within the margin of the disk, there is in many cases, but not so conspicuously in all, a wider or narrower strip of membrane, termed the velum or veil; and within the substance of the rim there is always a canal running round the entire circumference, and from this *marginal canal* four or more *radiating canals* pass, in the substance of the subumbrella or beneath it, towards the base of the peduncle, and which canals can, in many instances, be seen, and in most are supposed to open directly into the stomach or cavity communicating with it. I shall proceed to describe these various parts in *Turris neglecta* in the order above indicated.

The external integument of the disk, or the umbrella, is thick and firm, presenting faint indications of its being composed of cells mostly elongated and prismatic, but under more superficial examination it appears to be structureless: the external surface is covered with minute, circular, granular, slightly-raised spots, which constitute a sort of imperfect cuticular layer, but these scales or spots are not in close contact. The subumbrella is much thinner, and is connected to the former by a lax cellular tissue. It is composed almost entirely of muscular fibres, being in fact, it may almost be said, a muscular

expansion. The fibres are very distinct in nearly every part, but are especially strongly developed towards the summit of the bell and towards its lower margin: they are arranged in a circular direction, and I have not been able to observe the four distinct longitudinal bands of muscle described or rather figured by Prof. E. Forbes. The muscular fibres, or fasciculi, vary from $\frac{1}{1000}$ to $\frac{1}{2000}$ of an inch in width, and, as in the higher animals, are composed of smaller fibres or fibrillæ, distinctly marked with regular transverse striæ (fig. 8, *a*). The spaces between the muscular fibres are comparatively large. The border of the bell is somewhat thickened, containing the marginal canal, and to its lower margin are appended the tentacles and bulbs, or rudimentary tentacles. Attached to the inner margin of the border is the narrow and inconspicuous *velum*, which is to be regarded perhaps as a prolongation or continuation of the subumbrella, and like that part is composed almost entirely of concentric muscular fibres; it is the proper sphincter or contractor of the orifice of the bell. The deficiency in size of the velum is in some degree compensated by the greater development of the muscular structure of the subumbrella itself.

The inferior margin, as above stated, is beset with a close and crowded series of rounded or pyriform bulbs, all of which present a circular, crimson spot towards or at the lower part, and a more faintly coloured, somewhat elongated, yellowish brown spot towards the upper part. The tentacles arise from these bulbs, and when completely retracted appear to constitute the narrow pyriform prolongation exhibited by some, but not by all of these bodies. The tentacles vary very much in number: in a full grown specimen, and when all are fully extended, they are very numerous; in fact so much so as not to admit of being accurately counted. In length they exceed, perhaps, twice or three times the height of the bell, and form, when in the extended condition, a beautiful light fringe or halo around the animal as it sinks slowly in the water. When the creature ascends or swims about by the contractions of the disk, the tentacles are almost invariably drawn in entirely, or at all events much shortened. The bulbs are about $\frac{1}{250}$ or $\frac{1}{300}$ of an inch in diameter, and the tentacles considerably less. The bulbs and tentacles are constituted of a thin transparent membrane, the interior of which is filled with a delicate cellular tissue (fig. 12). The outer layer of cells of this tissue, have in the bulb something of a prismatic form. In the tentacles the shape of the cells is considerably altered, they become narrow and elongated, their long axis (in the contracted state of the

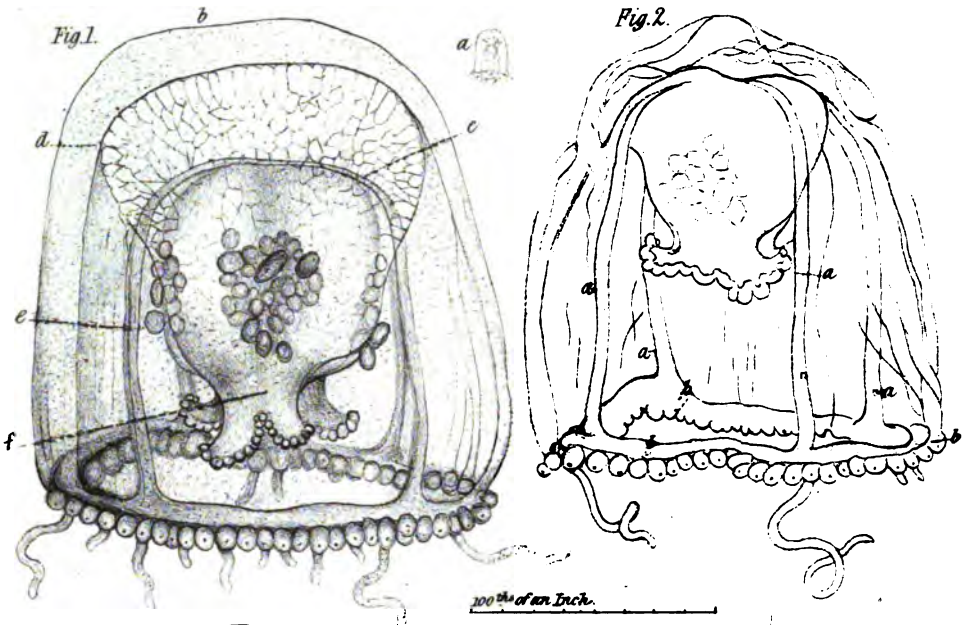
organ at least) being transverse; owing to this circumstance the tentacles, when partially extended, present the appearance of transverse compartments.

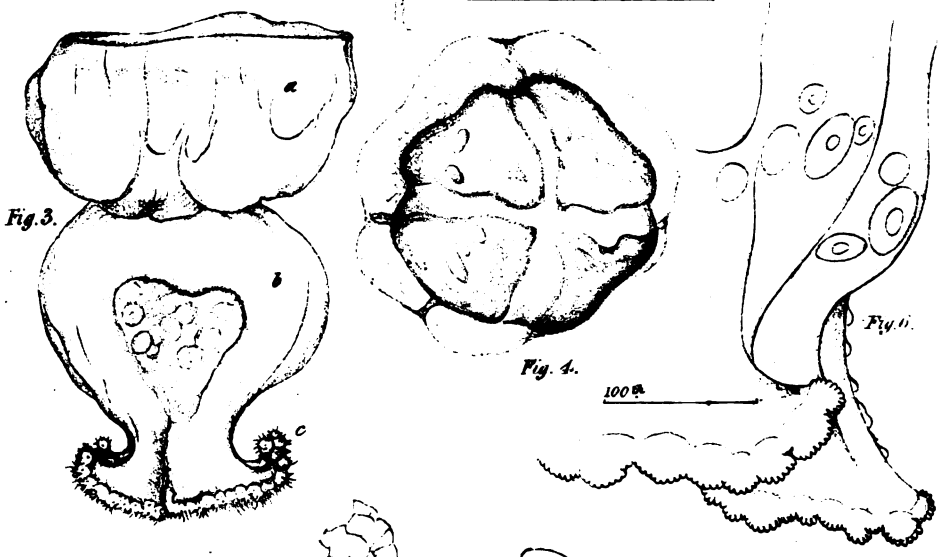
In the centre of the substance of the bulb there is a cavity which communicates, I believe, above with the marginal canal, and is continuous inferiorly with a tubular cavity in the centre of the tentacle. The immediate walls of the cavity in the bulb are formed of cells, having brownish coloured granular contents, and which I consequently presume are of a glandular nature, and to the presence of which cells is due the upper elongated brownish spot (*a*, fig. 12) mentioned above. The lower, circular, crimson spot is composed of tolerably uniform, coloured corpuscles or pigment grains, which seem to be lodged in the outer cells of the parenchyma, or between the parenchyma and the basement membrane of the bulb. It is, I believe, this assemblage of coloured granules that has been dignified with the name of "ocellus," though it seems to present few of the characters of a visual organ. The exterior of the bulb is covered with a thick layer of cells, each of which contains, or rather partially surrounds, one of the peculiar spiculiferous or filiferous vesicles, common in all the *Hydræ*, hydroid Polypes, *Actiniæ*, &c. On the tentacles themselves, these filiferous vesicles lose, or come out of, their parent cell, and assume the aspect under which they more commonly occur. In this form they exist, scattered more or less irregularly throughout the whole length of the tentacle, being, of course, more closely or more rarely set, according to the degree of extension of that organ. The *marginal* and four *radiating* gastro-vascular canals are all constituted in the same way. They appear to have a distinct but very delicate wall or basement membrane, which is lined by an epithelial layer of elongated cells (*d*, fig. 8) with large granular nuclei, and probably of a secretory or glandular nature. On the exterior of the basement membrane there are also placed similar cells, but not so closely arranged. Ciliary motion is evident throughout these canals, but the cilia themselves are inconspicuous. The fluid which circulates with considerable rapidity in these canals, carries along with it numerous corpuscles, mostly granular and of various sizes. The four gastro-vascular canals open directly into the marginal canal, and superiorly they penetrate the base of the peduncle. Soon after the entrance into the base of the peduncle (*c*, fig. 1), they become narrower, and appear to lose their distinct, defined wall or basement membrane, and to become mere channels between the cells, constituting the substance of the base of the peduncle presently to

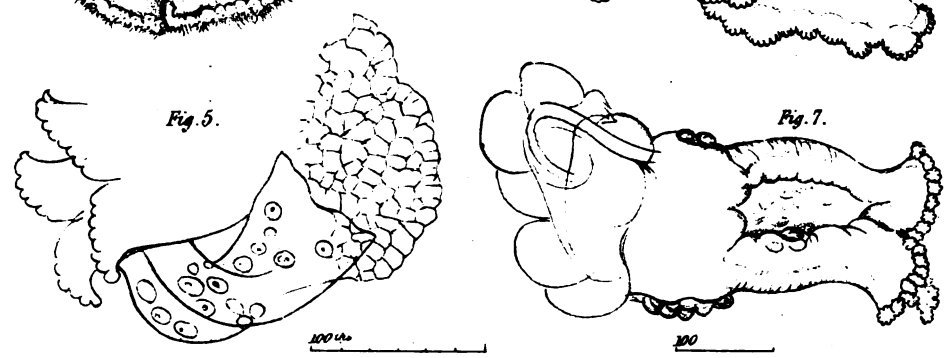
be described. The ultimate mode or even point of termination of these canals I was unable to make out satisfactorily. It seemed, however, that the current of fluid in the canal did not penetrate far into the base of the peduncle, but stopped at the point where the canal became contracted, and was there turned back. The peduncle, for convenience of description, may be divided into three portions; an upper portion or base, a central portion, and a lower portion constituting the mouth or lips. The upper portion or base (*d*, fig. 1) is the most expanded; it is colourless and transparent, and is composed of a beautiful, very distinct cellular tissue (using the term not in a sense very commonly understood of it as applied to the areolar tissue of animals, but to designate a tissue composed of distinct polygonal cells like those of certain vegetable tissues), as shown in fig. 1, and fig. 10. The cells constituting the greater part and the interior of this mass, are of irregular size and polygonal form, but towards the exterior, as in the tentacular bulbs, the cells composing the tissue assume more of a prismatic form, and thus constitute as it were a thick external layer, in some degree distinct from the rest of the mass. The subumbrella or its lining membrane appears to be reflected on the base of the peduncle, and to be lost or rather merged in its outer covering. The cellular base of the peduncle is penetrated, to a certain extent at least, as above described, by the four gastro-vascular canals, immediately contiguous to which, the cells of the cellular tissue are contracted and crowded. The cells of the cellular tissue are filled with a transparent colourless fluid, which is rapidly dissipated by exosmosis when the specimen is placed in a saline solution of greater density than sea water, or in spirit, and in this condition the cellular base of the peduncle, and together with it great part of the thickness of the umbrella, disappears, and the specimen assumes something of the appearance shown in fig. 2. The middle portion of the peduncle is of a quadrangular form and of a deep red or crimson colour: it consists of the thick walls of the stomach or digestive cavity, and on the four sides are placed the ovaries or reproductive glands. The walls of the stomach are thick and dense, composed of elongated closely packed prismatic cells, amongst which, and also on the external surface of the peduncle, are numerous granular corpuscles, fig. 11. The four angles are rounded and exhibit a rather laxer tissue, continuous above with that of the basal portion, and below with the four angular folds of the lips. The third or lowest portion of the peduncle is constituted of four fimbriated and scalloped crescentic folds; the sulci between which correspond to the four sides of the peduncle, and

along the middle of each fold or valve runs the thickened continuation of the angles of the peduncle, in which there is, most probably, a band of muscular fibres, though I have not been able to make this point out satisfactorily. The margin of the lips is thickened and slightly everted, thickly beset with filiferous and spiculiferous vesicles: when closed, the four valvular folds of the lips form a crucial slit. The ovaries or reproductive glands are placed on the four sides of the middle portion of the peduncle; each entire gland is bilobate and somewhat cordiform, with the apex directed downwards (fig. 3, 4), and it is enclosed as it were between the swollen corners of the peduncle; beyond the level of which, however, when mature, the ovary projects as shown in figs. 5, 6 and 9, which latter represents a portion of the mature ovary projecting from the surface of the peduncle. These glands (the female ones at least) consist of a delicate membrane, enclosing a granular or cellular stroma filled with ova in various stages of development. The ova probably escape at a certain stage of their development through ruptures of the membrane of the gland, adhering for some time after their escape from the interior to the surface of the ovary (fig. 1): they afterwards appear to fall into the cavity of the bell, in which there may frequently be observed numerous detached ova. How long they are thus carried about by the parent, or what degree of development (if any) they undergo whilst in this position, I am unable to determine. In one and the same ovarian gland, ova in all stages of development may be observed, and the smaller ones seem to be always attached by a short placental cord (*b*, *b*, *b*, fig. 8). The ova are of a rosy pink or crimson colour, and the fully mature ones are opaque. The colour of the peduncle appears to be due chiefly if not entirely to these bodies.

When specimens of *Turris neglecta* are kept for some days in the same water, they, like the *Actiniæ*, turn themselves inside out. At first the disk only appears to be reverted over the peduncle, as in figs. 3, 7; but as the retroversion proceeds, the lips or oval lobes are also reflected over the peduncle, and the stomach itself, as in the *Actiniæ* is turned inside out and reflected over the sides of the peduncle and ovaries.




G. Busk del.
S.W. Leonard lith.

Day & Son Lith to the Queen.

## EXPLANATION OF PLATE V.

Fig. 1. *a*. Natural size.
*b*. Magnified view of *Turris neglecta*.
*c*. Entrance of gastro-vascular canals into the base of the peduncle.
*d*. Cellular base of peduncle.
*e*. Middle portion of peduncle with ovaries and some detached but adherent ova.
*f*. Lower or oral portion of peduncle.

Fig. 2. Specimen corrugated by immersion in strong saline solution or spirit.
*a*, *a*, *a*, *a*. Four gastro-vascular canals.
*b*, *b*. Marginal canal.

Fig. 3. Specimen partially reverted.
*a*. Disk, turned back and the margin inflected.
*b*. Middle portion of peduncle, with the cordiform ovary.
*c*. Oral or labial portion.

Fig. 4. Specimen completely reverted, stomach turned inside out; the ovaries seen through its stretched walls.

Fig. 5. Side view of ovary partially detached at the base.

Fig. 6. Side view of ovary *in situ*.

Fig. 7. Specimen partially reverted; shows the thickened angles of the peduncle.

Fig. 8. *a*. Muscular substance of subumbrella.
*b*, *b*, *b*. Ova in an early stage of development.
*c*. Lining membrane of subumbrella, which appears often to contain nucleated cells.
*d*. Epithelial lining of canals.
*e*, *e*. More mature ova.

Fig. 9. Section of ovary, seen in profile.

Fig. 10. Cellular tissue of base of peduncle.

Fig. 11. Cellular tissue of wall of peduncle or stomach.

Fig. 12. Tentacular bulb and ocellus.
*a*. Upper spot or cavity of bulb. (The luminous gland?)
*b*. The lower spot or so-termed ocellus.

## IV.—*Observations on certain points in the Anatomy of a species of Thaumantias.* By George Busk, Esq., F.L.S., President of the Society.

(Read March 28th, 1849.)

The species of *Thaumantias* forming the subject of this paper, most nearly resembles *T. inconspicua* or *T. sarnica*, Forbes, from both of which, however, it appears to differ in the shape of the reproductive glands, which are not linear, as described in both those species, but short and ovate. From the former species, also, it differs in the absence of colour in the tentacular bulbs. The specific name, therefore, is left undetermined; but this is of the less consequence, as the subject of this paper is merely to describe certain points of anatomical structure presented by this species, in common with many others; and in a modified form, perhaps, by all its congeners.

It was very abundant last autumn in the sea between Portsmouth and the Isle of Wight, a locality apparently very favourable to the smaller and more delicate species of gymnophthalmatous *Medusæ*.

This *Medusa* is about three-fourths of an inch in diameter, and the disk is rather depressed; varying, however, a good deal in this respect (fig. 1, *a*, *b*). It is perfectly transparent and colourless in all parts. The subumbrella ascends to about three-fourths of the height of the umbrella. The margin of the disk is furnished interiorly with a pretty wide velum, and supports from eight to thirty-two tentacles according to the age of the animal. The age may probably be correctly deduced, not merely from difference in size, but from the greater or less completeness in the development of the reproductive glands. The peduncle contains a simple cavity, into the base of which the four gastro-vascular canals seem to open directly. The margin of the lips of the peduncle is entire, and when the organ is contracted, this part and the greater portion of the peduncle itself is thrown into four angular folds (fig. 2). The substance of the peduncle and lips is composed of a fine cellular tissue, and the margin is slightly thickened and beset with filiferous vesicles, as indeed in a less degree is the whole surface of the peduncle. Four principal

bands or fasciculi of striped muscular fibre correspond to the four angles of the peduncle, and are no doubt the agents by which its active movements in all directions are effected. The four gastro-vascular canals run in a straight course from the base of the peduncle to the marginal canal, giving off from their inferior aspect, and at about two-thirds of their length, taken from their entrance into the peduncle, a short, narrower tube, which running down a short way parallel with the main trunk, terminates in the reproductive gland or ovary; and this short, narrow oviduct, as it may be termed, is lined with very long vibratile cilia, which might readily under some circumstances be mistaken for *Spermatozoa*. The gastro-vascular canals and the marginal canal are all lined with a glandular epithelium, by which term is meant an epithelium composed of cells containing a solid granular matter, and which probably are of a glandular or secretory nature. There is an active circulation of fluid in these canals. The marginal tentacles, as has been said, vary considerably in number, and they may usually be observed in all stages of development. The perfect tentacle consists of a pyriform bulb which is prolonged into the filiform tentacle. These bulbs are situated on the margin of the disk, from which they project (fig. 3). They contain a cavity which is continuous above with the marginal vessel, and below with the tubular cavity of the tentacle (figs. 6, 7, 8, and 9). The cavity of the bulb is lined with, and in fact its walls as well as those of the marginal canal are constituted of solid glandular cells (figs. 6, 11). These cells, in the cavity of the bulb, I believe to have the property of secreting a luminous material, and indeed to be the principal seat of the luminosity in the present species. A faint blue luminosity may be noticed in these bulbs even by subdued daylight, when the animal is placed in fresh water and quickly examined under the microscope; and in the dark the phenomenon is very striking. The tentacles have a remarkable power of elongation, and when elongated are thrown into very extraordinary angular curves. At each of these angular bends projects a large filiferous or spiculiferous vesicle. The extremity of the tentacle is slightly dilated, and is thickly beset with similar prehensile vesicles. To this part of the tentacles I have frequently found adherent numerous, globular or elongated cells, containing rounded corpuscles and endued with an active motion. These bodies I looked upon as the sporules of *Algæ*, and as forming probably part of the aliment of the *Medusa*.

The formation of the tentacular bulbs appears to commence in a circumscribed dilatation of the marginal vessel, as shown in *a*, figs.

[illegible] accumulation of glandular [illegible] of the walls of the [illegible] cavity of the [illegible] the tube of the tentacle. The [illegible] is for the first thickly beset [illegible] glands [illegible] a great many exa- [illegible] contained one in vari- [illegible] the margin of the disk and [illegible] glandular marginal bodies or organs, to which I [illegible] as it appears to [illegible] their true nature, and [illegible] by different observers. [illegible] usually assume, is shown [illegible] figs. 13, 14. They con- [illegible] envelope of consi- [illegible] a cyst or cysts filled with [illegible] a spherical highly refractive [illegible] than one of these corpuscles, and [illegible] contained in a dis- [illegible]. The cavity of the outer cell [illegible] the smaller or inner cyst which contains the re- [illegible] in a fine granular material, in which [illegible] may sometimes be de- [illegible] the inner cyst may be seen. besides the [illegible] other small marginal sized spherules, as [illegible]

[illegible] exhibits a well-de- [illegible] which may probably be [illegible] gradually and uni- [illegible] structure would [illegible] that of the crystalline lens, and [illegible] closely similar in form and [illegible] These marginal bodies [illegible] organs and not as auditory [illegible] been usually considered.

[illegible] indistinctly cellular. That of [illegible] the most part of a muscular expan- [illegible] membrane, and between these [illegible] appear to run. The velum also is com- [illegible] muscular fibres. All these muscular fibres are

distinctly marked with transverse *striæ*, and are assembled in fasciculi of various sizes and lengths.

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ADDENDUM TO THE FOREGOING PAPERS.

As the nature of these marginal bodies is perhaps still obscure, and its determination a matter of interest, I have endeavoured to collect all the more important observations hitherto made with regard to them, and the result is as follows.

Though noticed and imperfectly described and figured by Ehrenberg and Milne-Edwards, no connected account of the varieties presented by these bodies in various species seems to have been afforded before that given in Dr. Will's 'Horæ Tergestinæ,' published in 1844; a work which cannot be too highly praised. The substance of what he says of the marginal bodies, termed by him "auditory capsules," is included in the following summary.

"1. In *Cydippe* the auditory capsule is pedunculated, and consists of a simple but tolerably thick membrane and a round mass of crystals, of a reddish-gray colour in *Beroë*, but white in *Eucharis* and *Cydippe*. Between the inner surface of the cyst and the crystalline mass is a transparent interspace of considerable width, which appears to be filled with a fluid, for the cyst is not only always distended to the utmost, but also changes its figure according to the shortening or extension of the infundibulum; in the former instance becoming globular, in the latter elongated. The granules are slightly transparent, roundish or of a compressed reniform shape. Examined in oil of turpentine their form becomes more distinct. They are dissolved with effervescence by muriatic acid. Their number varies according to age and the species. In the auditory capsule of *Beroës*, two inches long, I have counted about two hundred, and as many in *Eucharis*, but in *Cydippe* not more than twelve to fifteen."

"I have never succeeded in observing any motion in these crystals, or ciliary movements on the inner surface of the cyst, as has been observed by Kölliker and Siebold in the Mollusca, either in the Ctenophorous or Discophorous *Medusæ*, although I have employed a good microscope by Schieck, and sufficiently great magnifying powers (*l. c.* p. 45 and 46)."

He was equally unsuccessful also in observing any motion in the

corpuscles contained in the marginal capsules in *Geryonia pellucida* (p. 46.)

In *Cephea Wagneri* (Will), a covered-eyed species, the auditory capsule is thus described: "It is about one-sixth of a line in size and placed upon a thick stem, which arises from a transparent yellowish mass, placed in the excavation of the more compact bean-shaped substance (described as situated in the nine deeper marginal incisures). The upper border of this substance is deeply excavated on the sides, the lobes extend far into it, and below, a membrane is stretched across. In this way the auditory capsule is entirely covered, and can even be partially retracted. It consists of a delicate membrane, crammed full of hexahedral crystals from the one-hundredth to one-eightieth of an inch in diameter. The circulation of fluid seen by Ehrenberg in the stem, is only a part of that produced by ciliary movement in all the aqueous passages; a motion of the water resembling circulation."

In *Polyxenia leucostyla*, a naked-eyed *Medusa*, the marginal bodies are thus described:—"They are placed in the middle, between the marginal tentacles, close upon the marginal vessels. Their number is very inconstant, and does not always correspond with that of the tentacles. They have a slender peduncle (?) by which they are affixed to a yellowish substance lodged in a slight incurvation of the marginal vessel, from which, however, it projects pretty considerably. Although the vesicle has a double marginal shadow, still I believe that it consists of only a single membrane. With respect to its contents, it differs from all known forms in the circumstance that it contains only a single perfectly spherical corpuscle, almost entirely filling the vesicle, and applied close to the inner wall for two-thirds of the periphery. I was unable to remark any motion in it. It is dissolved by dilute muriatic acid."

In *Cytæis polystyla*, a naked-eyed species, the so termed auditory capsules are not placed between the tentacles as in the former instance, but beneath, or on the inner side of the tentacular bulb, whether there be a tentacle prolonged from it or not. They are not pedunculated, but placed immediately beneath the epidermis, about the one-hundred-and-fiftieth of an inch large. They contain a great number of intensely reddish-yellow roundish corpuscles, with an irregular jagged outline. They are soluble with effervescence in muriatic acid.

In *Geryonia pellucida* (Will), a naked-eyed species, "The capsules are placed on the marginal vessels in very inconstant number;

usually, however, there is one on each side of the larger tentacles, but only on one side of the smaller. They are round, one-fortieth of a line in diameter; consist of a tolerably thick membrane, and contain one to nine and even more round corpuscles. If there is only one corpuscle, it is lodged exactly in the middle of the vesicle; but when more are present, they are placed either in two groups, together, or arranged in a single row at the border of the vesicle (beisammen oder eigeln ane inauder gereiht). Their size varies from the one-three-hundredth to the one-hundred-and-fiftieth of an inch. I have never observed motion in them. Muriatic acid dissolves them and causes the vesicle to collapse. At the point where the latter is placed upon the marginal vessel there is a slight depression; this is filled up by a yellowish-green substance, in which the vesicle itself is imbedded to the extent of one-third of its circumference. This structure I look upon as a ganglion, although histologically this cannot be demonstrated."

In *Geryonia planata*, the structure of these bodies would appear to be the same as in the above.

In *Thaumantias leucostyla* (Will), also a naked-eyed species, "The auditory capsules are stated to be situated below the basis of the marginal tentacles on a minute projection. They are about one-sixtieth of an inch in diameter, and contain a corpuscle one-two-hundredth of an inch in size. They do not occur under all the tentacles."

In *Ephyra*, a covered-eyed species, the marginal vesicles are placed in the angle between the two terminal lobes of each segment, upon a thick peduncle; they are completely filled with about thirty rhomboidal crystals, the largest of which are the one-hundred-and-fiftieth of an inch in length, and the two-hundredth in width. The vesicle itself has a diameter of one-fiftieth of an inch, and only two-thirds of its circumference are free. The other third is imbedded in a round or elongated cellular substance very distinct from the substance of the body, by its less pellucidness and a yellow colour. The peduncle is the continuation of an elevated sharp ridge, running from the mouth to the middle of each lobe on the under surface, and is continued somewhat outwards on the latter itself, where it is gradually lost. But at the point where the middle third of this ridge forms the peduncle of the auditory capsule, it appears as if this peduncle had four angles, two more prominent on the inner side, and two less distinct on the outer.

What is said respecting these marginal bodies, in the beautiful

Monograph of Prof. E. Forbes, is not very satisfactory, as that eminent observer does not appear to have noticed their peculiar structure, as detailed by Will, and as described in the foregoing paper. He says (*l. c.* p. 8) that "the otolitic vesicle, which from analogy and its peculiar structure, is considered an organ of hearing, is a small spherical sac, developed in the midst of the granular substance of the bulb [of the tentacles] and containing more or fewer vibrating bodies." He then proceeds to give Will's description of the marginal vesicle in *Geryonia;* overlooking, apparently, the fact that the writer both describes and figures these vesicles, in that species at least, as quite distinct from the tentacular bulbs; and, moreover, that Will repeatedly denies that he ever observed any vibratory motion in their contents. Neither does Will nor Milne-Edwards anywhere describe these bodies as developed in the midst of the granular substance of the bulb; for in cases, such for instance as *Cytæis polystyla* and *Thaumantias leucostyla*, described by the former writer, where the marginal vesicles are placed, not intermediate to the tentacles, but beneath or covered by their bases, still they are said to be "immediately beneath the cuticle."

It would have been strange, however, had not such an accurate and close observer as Prof. E. Forbes, noticed these bodies at all. Such is not the case; although he does not appear to have paid any very close attention to them. In the description of *Thaumantias globosa* (p. 46) it is said, "here and there among the tentacles are little colourless tubercles studding the margin;" and in that of *T. inconspicua*, which is not improbably the species I am describing, it is noticed, that "between each pair [of tentacles] there is a rudimentary marginal tubercle." With respect to *Thaumantias quadrata*, Prof. E. Forbes notices and figures (Plate IX. fig. 2 *e*), what I presume to be the marginal bodies, as "intermediate bulbs," from which it might almost be presumed that he looked upon them as incipient tentacular bulbs. In the figures also of

*Thaumantias octona*, Plate VIII. fig. 4 *b* and 4 *e*.
*Thaumantias maculata*, Plate IX. fig. 4 *e*.
*Thaumantias globosa*, Plate X. fig. 4 *g*.
*Thaumantias inconspicua*, Plate VIII. fig. 3.
*Modeeria formosa*, Plate VII. fig. 1 *f*.
*Oceania turrita*, Plate II. fig. 2 *c* and *d*.
*Oceania episcopalis*, Plate II. fig. 1 *b*.
*Oceania octona*, Plate II. fig. 3 *b* and *c*.

Are represented what I conceive to be the marginal corpuscles, but

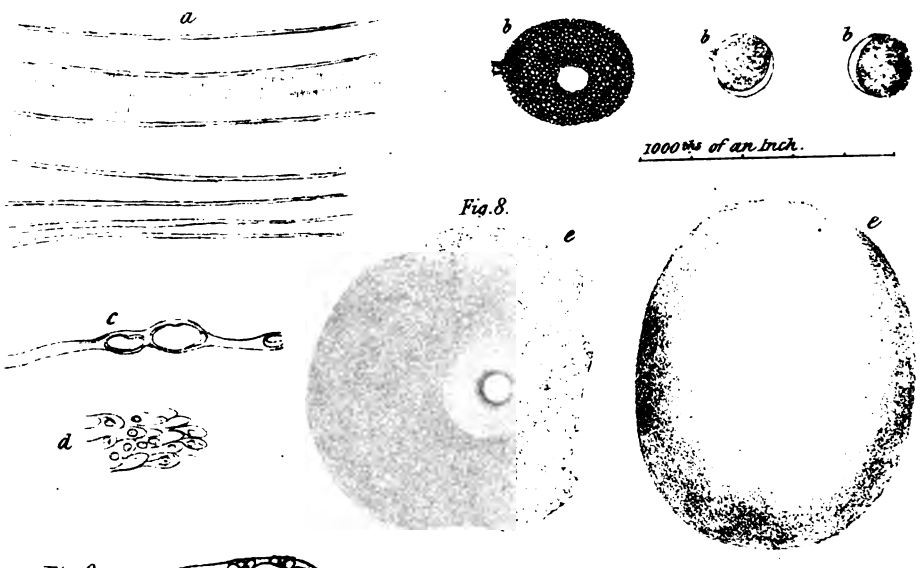
merely as minute rudimentary bulbs. It would seem, therefore, that Prof. E. Forbes has considered the cavity of the bulb in certain species, in which occasionally an active vibratory or rather rotatory movement of irregular-sized particles is to be observed, as corresponding to the so-termed auditory vesicle of Will, &c. That this is not the case, however, is abundantly clear, and, though speaking with much diffidence, owing to the want of observation in a sufficient number of species, I am inclined to agree, I believe it is with Will, in thinking that the rotatory movement above described (in the naked-eyed *Medusæ* at all events) is to be referred to the existence of a sort of vortex or torcular at the point where the cavity of the bulb joins the marginal canal.

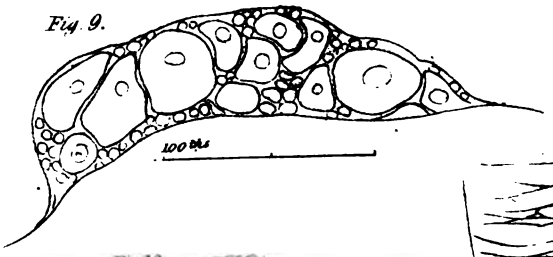
The true nature of these marginal bodies is still obscure; but from what has been noticed with respect to the intimate structure and optical properties of the spherical body or bodies contained in those of the naked-eyed class, it is not an improbable supposition, that these little organs are visual and not auditory. Allowing also, as can perhaps scarcely be denied, that the marginal vesicles above described are homologous with the peculiar bodies regarded, I believe by all, as the *eyes* of the covered-eyed species, this supposition would appear to be much strengthened.

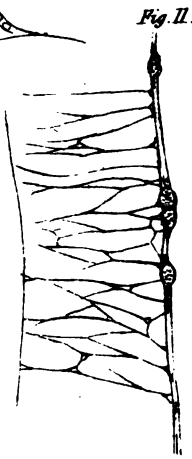
I would here also call attention to the remarkable fact, that these marginal vesicles in the *Gymnophthalmata*, where present, are almost invariably, if not always, sessile (*Polyxenia* and perhaps *Cytæis*, according to Will, offering an exception), and contain but one or but few spherical corpuscles; whilst in the *Steganophthalmata*, as also in the *Beroidæ*, they are always pedunculated, and filled, not with spherical lenses, but with a mass of crystals. The former class would, therefore, seem to have the better eyes of the two. It is to be remarked with regard to the chemical constitution of these lenses, that, although their solubility in dilute acid with effervescence appears to be universally allowed, and consequently that they are of a calcareous nature, yet that in the naked-eyed species at least, upon immersion of the *Medusa* in spirit of wine, these spherules immediately become opaque, as an optic lens in other cases would.

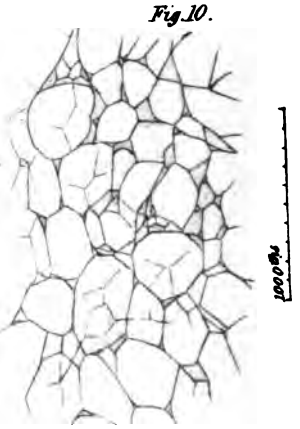
The bean-shaped, granular, opaque substance, from which the peduncle in the case of the *Steganophthalmata* springs or appears to spring, may perhaps be regarded as homologous with the granular, indistinctly fibrous mass, in which the internal cyst containing the lens is partially imbedded in the other.

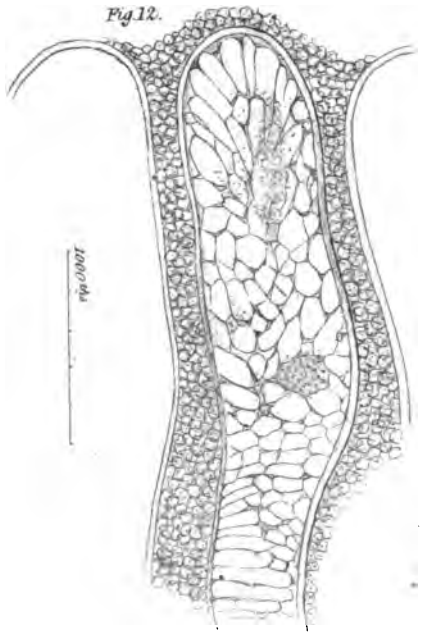
In an excellent and most valuable paper by Mr. Huxley, on the "Anatomy of the *Medusæ*," published in the last part of the 'Philosophical Transactions,' and which has come into my hands since the above observations were written, I am glad to find that the account given of these marginal corpuscles, agrees very nearly if not exactly with that contained in my paper, and as far as they go, with the prior observations of Will on the same bodies. Mr. Huxley does not, however, express any opinion, or even use any term, from which his notion of the true nature of these bodies can be deduced.

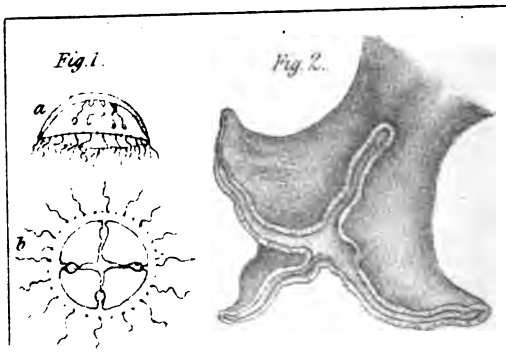



C. Busk. del
S.W. Leonard. lith.

Day & Son Lith^rs to the Queen

Fig. 4.

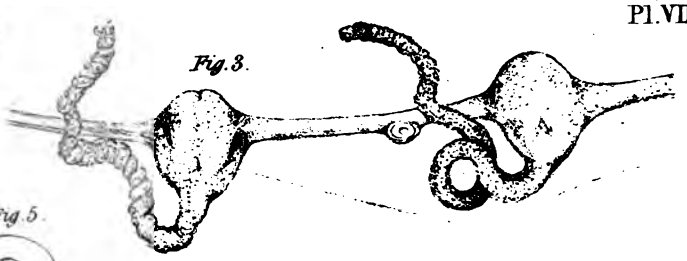


Fig. 3.

Fig. 5.

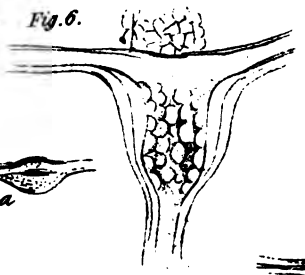


Fig. 6.

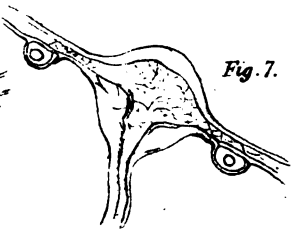


Fig. 7.

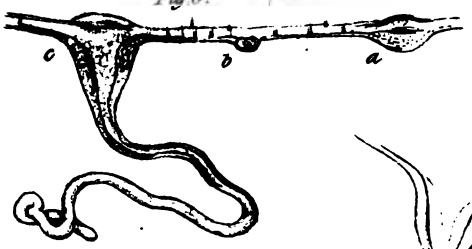


Fig. 8.

Fig. 10.

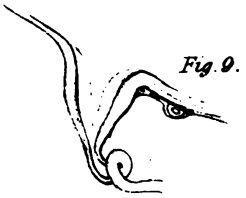


Fig. 9.

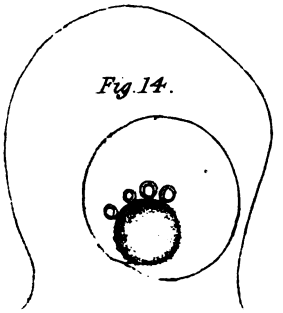


Fig. 14.

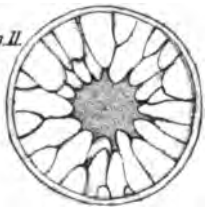


Fig. 11.

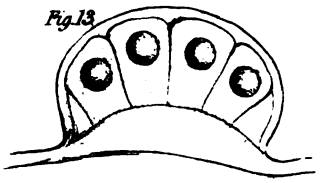


Fig. 13.

Fig. 12.

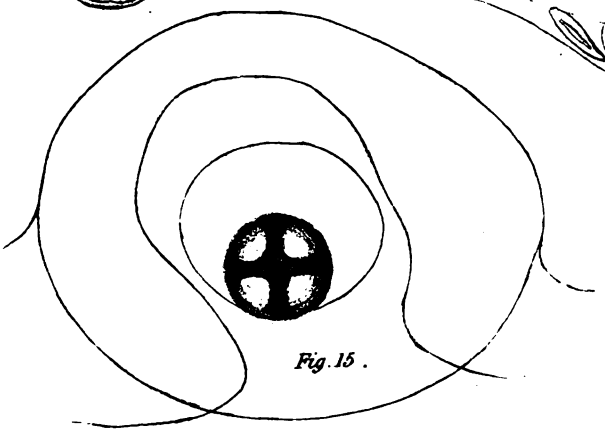


Fig. 15.

Fig. 16.

G. Busk del.
S. W. Leonard lith.

Day & Son, Lith.rs to the Queen.

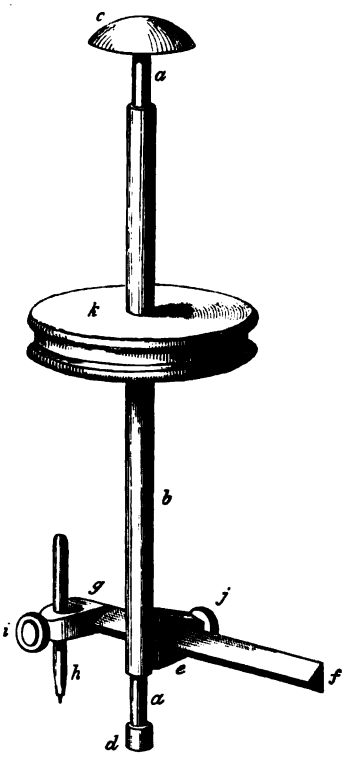
## EXPLANATION OF PLATE VI.

Fig. 1. A side view of *Thaumantias*, natural size.
*b*. View from beneath.
Fig. 2. The lips and part of peduncle.
Fig. 3. A pair of tentacles, with an intermediate marginal vesicle.
Fig. 4. One of the ovaries.
Fig. 5. Do., immature.
Fig. 6. Section of tentacular bulb lined with glandular cells.
Fig. 7. Do., showing the respective positions of the tentacular bulbs and marginal vesicles to the marginal canal.
Fig. 8. *a*. Rudimentary tentacular bulb.
*b*. Marginal vesicle.
*c*. Tentacle and bulb.
Fig. 9. Another view of tentacular bulb and its sometimes infundibuliform cavity.
Fig. 10. Incipient tentacular bulb.
*a*. Upper wall of marginal canal, becoming thickened.
*b*. Marginal vesicle.
*c*. Lower wall of marginal canal, thickened, and thickly beset with filiferous vesicles.
Fig. 11. Highly magnified transverse sectional view of tentacular bulb.
Fig. 12. A marginal vesicle with a solitary lens.
Fig. 13. Do., with four lenses.
Fig. 14. A more highly magnified view of a marginal vesicle with one lens, and smaller spherical bodies having a double contour.
Fig. 15. A view of a marginal vesicle magnified with a power of 450 linear, and under polarized light; showing the black cross formed by the lens, and an indistinct granular appearance in the chamber in which it is lodged. This space under ordinary light appears quite transparent and clear. A vitreous humour?
Fig. 16. *a*. Filiferous vesicles imbedded in incipient tentacular bulb.
*b*. Others detached and more highly magnified.
*c*. One with the filament and neck-like process extruded.
*d*. A portion of the muscular expansion of the subumbrella.

V.—*The "Disk-cutter," a New Instrument for cutting circular Disks of thin Glass for Mounting Microscopical Objects. Also the description of a Collecting Stick for procuring Infusoriâ, &c.* By GEORGE SHADBOLT, Jun., Esq.

(Read October 25th, 1848.)

As the principal object of the meetings of this Society is the interchange of ideas among the members, on all matters connected with microscopical science, I shall make no apology for describing the subjects of the present paper, considering, that they may be of interest to some, and that it is preferable to occupy attention for a short time, for that which may prove of little value, rather than by abstaining from doing so, running the chance of leaving uncommunicated what may possibly prove of use.




Few people who have made much use of a microscope, can have failed to appreciate the use of circular disks of thin glass for mounting some objects (particularly such as require to be in cells) and for other purposes, such as repairing a broken live-box, &c. Having myself constantly found occasion for glass disks, and as frequently as not found that what I had by me were not of a suitable size, I made use of various schemes for cutting them, and after rejecting several, contrived the instrument figured in the annexed drawing, which I find answers the purpose completely.

A steel rod, *a a*, runs through a brass tube, *b*, having at one end an ivory head or handle, *c*, and at the other a cylinder of wood, *d*, about the same diameter as the tube *b*. The tube has attached to its lower extremity,

and at right angles to it, a small flat piece of metal, *e*, of the form of a trapezium, having in it a triangular hole, through which a triangular bar, *f g*, works, which bar has at the extremity, *g*, a flat piece also projecting at right angles from it, and in the opposite direction to the piece, *e*. Through the piece, *g*, is drilled a circular hole to carry a small cutting diamond, *h*; at *i* and *j* are two screws with milled heads, the former for holding the diamond firmly, and allowing it to be adjusted to its best cutting edge, or to be removed; and the latter for holding firmly the triangular bar, *f*, after it is adjusted, so that the diamond point will be distant from the centre of the cylinder, *d*, equal to the radius of the circle required to be described. The triangular bar may have marked on it a scale for fixing it to any requisite radius. Attached to the brass tube, *b*, is a wooden disk, *k*. The tube is about half an inch shorter than the steel rod which runs through it, and the former turns on the latter easily. The lower end of the cylinder of wood, *d*, should be made quite flat, and roughened by sand-paper.

To use the instrument, take hold of it by the brass tube just above the wooden disk, *k;* with the fore finger and thumb of the right hand, place the end, *d*, on to the thin glass to be cut, and hold the ivory handle, *c*, with the left hand, so that the rod is in a perpendicular position; allow the diamond point to come down upon the glass, and cause the whole, with the exception of the steel rod, to revolve, exerting a slight pressure on the disk, *k*, according to the thickness of the glass to be cut. When the revolution is complete the disk will readily separate.

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In collecting *Infusoria*, &c., for microscopical investigation, it is often necessary to approach pools of water in very swampy localities, as it is in such situations that the best specimens are most frequently met with; for this and for other reasons a long stick to hold the bottle for procuring them is highly useful.

I, in common with many others, have found an ordinary "walking-stick fishing-rod," or rather, the two lower joints of it, very convenient for the purpose. Various contrivances have been resorted to for the purpose of attaching the bottle to the stick, and it is my method of doing this, that I purpose describing. I should premise, that the points I have aimed at achieving are, first, capability of holding a bottle of any reasonable size, and secondly, capability of being included within the stick, so that with stick alone, and a bottle or two of any kind, that may be at hand, in the pocket, one would be

ready to appropriate any animalcules that fortune might throw in the way.

Fig. A.

Fig. A, shows the stick when packed up; *l*, being a wooden top, and *m*, a brass ferrule, both of which unscrew. The cane being hollow, contains a smaller one, also hollow, and in this smaller one is a slip of thin whalebone. Fig. B, shows the brass end which is

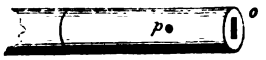


Fig. B.

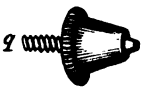


Fig. C.

fitted on to the inner cane; this brass piece having a flat hole (shown at *o*), running longitudinally through it; also a small screw hole in the side (shown at *p*). Fig. C, shows the brass ferrule detached from the outer cane, and which is furnished with a small screw, *q*, to fit the hole, *p*, in fig. B. The slip of whalebone should (after being taken out) be folded with its two ends together, and both of them be inserted into the flat hole, fig. B, *o*, thus forming a hoop, fig. D, *r*, into

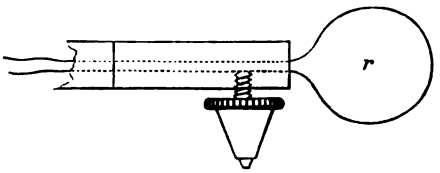


Fig. D.

which the neck of the bottle to be used is to be placed; the whalebone is then to be pushed as far into the hole as it will go, and the screw, *q*, of the ferrule, fig. C, screwed into the small side hole, *p*. This will attach the bottle firmly to the stick, which can be used by itself or added to the outer cane to lengthen it, as occasion may require.

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*Note by the Editor.*

At the succeeding meeting (November 22), the Assistant Secretary produced and described an exceedingly simple modification of this collecting-stick. It consists merely of a strip of thin whalebone, a

quarter of an inch wide, and about eighteen inches long, and three brass curtain-rings. Two of these rings fit loosely over the end of a common walking-stick. The strip of whalebone is bent into a loop, and the ends being applied to the sides of the end of the stick, are firmly secured by two of the rings; the one being brought up over them from below, and the other applied at the upper end, leaving an interval of two or three inches between them. The third ring, which is considerably smaller than the other two, is employed for contracting the sides of the aperture formed by the strip of whalebone: a small wide-mouthed bottle with a rim being now slipped into the loop is held firmly, and can be employed in collecting animalcules. When no longer required, the whalebone and rings can be instantly removed, and the apparatus becomes an ordinary walking-stick. By using rings of suitable sizes, the same contrivance can be applied with equal facility to an umbrella. The advantages of this modification are, its extreme portability, its cheapness (the whole cost not exceeding a few pence), and the readiness of its application to articles ordinarily carried by persons in their country excursions. The accompanying figures will fully explain the mode of fixing this piece of apparatus to a walking-stick and umbrella.

Fig. 1.

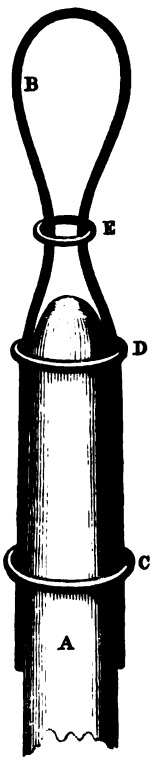


Fig. 2.

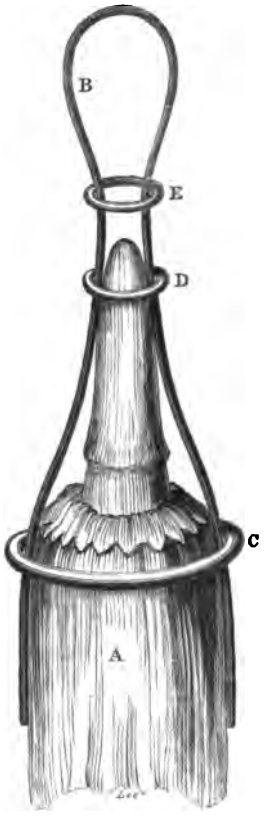


Fig. 1. A, the end of a walking-stick. B, the strip of whalebone. C, the lower ring brought up from beneath. D, the upper ring applied over the top. E, the small ring to contract the loop.

Fig. 2. A, The end of an umbrella. B, C, D, E, as in fig. 1.

## VI.—*On the Markings on the Scales of the Amathusia Horsfieldii.*

By Warren de la Rue, Esq., F.R.S.

(Read December 20th, 1848.)

Between two and three months since, my attention was directed by Mr. Topping to some peculiar markings on the scales taken from a wing of one of the *Lepidoptera;* the peculiarity, in his opinion, consisted in the markings being minute scales or featherings upon the upper surface of the ordinary scale, certainly a very remarkable structure if its existence were corroborated. With the view of testing the accuracy of this opinion, the object was brought to me for examination with a one-twelfth object-glass, as Mr. Topping had at his command no power higher than a one-fourth of sixty degrees, which he rightly judged was insufficient to enable him to form a correct opinion as to the reality of the structure exhibited. On submitting the scales to a scrutiny under a one-twelfth of one-hundred-and-ten degrees aperture, the object being illuminated with a one-fourth of sixty degrees, the illusion of the small featherings was immediately dispelled, and the markings shown to consist of rows of dots, immediately over the striæ, or else to arise, partly or entirely, from constrictions of the striæ themselves. The real nature of these markings, and their exact position on the scale have, however, been the subject of much discussion amongst my friends; and this is not surprising, when we reflect that markings on one layer of a series of superposed membranes, must necessarily interfere with the definition of those on another, and that this difficulty increases as the thickness of the membranes decreases. Hence the great desideratum of an object-glass of large aperture, and allowing of sufficient distance between itself and the object, for illumination of the latter as an opaque body by reflected light, such an objective would at once remove the difficulty alluded to, as regards the outer surfaces of an object, and would afford many other facilities in the investigation of minute structures.

With the idea that the distribution of lithographs of remarkable objects amongst microscopists was desirable, I amused myself in my leisure by making a drawing of one of the scales on stone, not intending to pursue the subject any further; Mr. Topping, having, however,

procured for me a perfect specimen of the insect, and assisted me in mounting numerous scales, taken from various parts of the wings, an opportunity was afforded me of extending the inquiry, and I was induced to draw up the present communication, under the impression that the result of the investigation might have some interest for the members of the Society.

I may premise that the insect, from which the scales were obtained, is the male *Amathusia Horsfieldii* (Kollar) or the *Amathusia Inachus* (Boisduval), it is represented at Plate VIII. fig. 8; the colour of the upper surface is a deep brown, of velvety aspect, besprinkled with blue near the shoulders, the upper wing being marked with a broad orange band, and two small white spots. The under surface of the wings is of a pale brown, richly marked with a darker brown.

The scales of the *Amathusia Horsfieldii* vary considerably in size, shape, and in the distance and character of their markings, even when taken from the same part of the wing. In Plate VIII. are delineated some of the more remarkable scales, as seen when magnified two hundred and ten diameters; a dozen plates, however, would not contain all the varieties. Figs. 1, 3 and 4, represent scales from the under side of the upper wing near the shoulder. In fig. 1, the longitudinal striæ are a ten-thousand-two-hundred-and-fiftieth of an inch distant, and tolerably regular, the transverse striæ being as close as from a thirty-thousandth to a twenty-thousandth of an inch; the latter when magnified eight hundred diameters, split into very distinct dots. The longitudinal and cross striæ of the scale (fig. 3) are about a ten-thousandth of an inch apart, the markings having the character of those represented in the large drawing, Plate IX. In the scale (fig. 4) the longitudinal striæ are a twenty-thousandth of an inch apart, and the cross striæ a thirty-five-thousandth of an inch.

Figs. 5 and 6, represent that modification of the scale which constitutes the hair, and fig. 7 a narrow scale, of a structure approximating to that of the hair; these were taken from the top side of the under wing, near the body. Neither cross nor longitudinal striæ can be made out with distinctness, though the same structure is seen to exist, but so much compressed, as to render its definition difficult; the hair was measured and found to be the three-thousand-seven-hundred-and-fiftieth of an inch broad.

Figs. 9, 10 and 13, are from the under side of the tip of the upper wing. In fig. 9, which is one of the scales possessing the peculiar markings, the longitudinal striæ are from a ten-thousandth to a six-thousand-eight-hundredth and a five-thousandth of an inch apart, the

transverse being from a twenty-thousandth to a ten-thousandth. In the scale (fig. 10), the longitudinal striæ are a thirteen-thousandth, and the cross striæ a thirty-thousandth of an inch apart, and are not very distinct. In the scale (fig. 13) the longitudinal striæ are from a twenty-thousandth to a thirteen-thousandth of an inch apart, the cross striæ being a thirty-thousandth of an inch distant.

Figs. 11, 12, 14 and 15, are from the upper side of the tip of the upper wing; in the scale (fig. 11) the longitudinal striæ are a twenty-thousandth of an inch, and the cross striæ from a thirty-thousandth to a twenty-five-thousandth of an inch apart; both are very distinctly brought out by a power of eight-hundred diameters. In fig. 12, the longitudinal striæ are a fifteen-thousandth, and the cross striæ from a thirty-five-thousandth to a thirty-thousandth of an inch apart. In fig. 14, the longitudinal striæ are a ten-thousandth, and the cross striæ vary from a thirty-thousandth to a twenty-thousandth of an inch distant. In fig. 15, which represents one of the characteristic scales, the longitudinal striæ are from a ten-thousandth to a seven-thousandth, and the cross striæ from a thirteen-thousand-five-hundredth to a ten-thousandth of an inch apart. All these drawings were made with the aid of the camera, the details being filled in on the stone by the eye; the scale of thousandths of an inch which accompanies them was likewise set off by the camera. The measures are from centre to centre of the markings.

I now come to the consideration of the real nature of the markings of the *Amathusia Horsfieldii;* before doing so, however, I wish to call attention to a paper by my friend Mr. Bowerbank, entitled 'On the Structure of Scales on the Wings of Lepidopterous Insects.'* This gentleman, after minutely describing the methods adopted to dissect out, and exhibit the structure of the scales, comes to the conclusion that they consist of three distinct layers, *viz.*, the upper membrane, which contains the colouring matter; the striæ, which constitute the frame; and lastly, the under membrane, which is nearly colourless; and finally, that the striæ are in reality tubes.

In Plate IX. is delineated one of the characteristic scales magnified eight-hundred-and-twenty-five diameters. The outline of this drawing was first made with a power of two-hundred-and-fifty diameters, and by means of proportional squares enlarged to the size corresponding to the magnifying power produced by the twelfth; a scale of thousandths of an inch being set off with the

* 'Entomological Magazine,' Vol. v. page 300.

camera in each case, to afford the standard of comparison. The drawing was then corrected in detail, by portions set off with the higher power, which were found to match the enlarged drawing with tolerable accuracy; in this way a very fair representation of the scale and its markings was produced. The cross striæ, when viewed with a twelfth of a hundred-and-ten degrees aperture, and illuminated with a quarter of sixty degrees, used as an achromatic condenser, and adjusted well to focus, came out under a power of eight-hundred-and-twenty-five diameters in beaded lines, on which protuberances were distinctly seen; these latter, when focused at their summits, appeared as brown dots. The longitudinal striæ, under the same circumstances, have likewise a somewhat corrugated appearance, but not so marked, and at the upper surface similar dots. In Plate VIII. fig. 2, accompanied by a scale of ten-thousandths of an inch, is represented a portion of the striæ at the lower focus, as seen with a power magnifying nineteen-hundred diameters, though the drawing is made for convenience, to a scale of forty-four-hundred to one. The scale when viewed from the under side with this power, exhibits the lower membrane as slightly undulating, probably from its being dry.

Some of my friends have thought that the constricted appearance of the cross striæ, just described, is due to the overlaying pigment-cells; this, in my opinion, is not correct; as I have convinced myself by careful and repeated examinations, more especially from the under side, that the striæ themselves are really beaded; it is true that the pigment-cells correspond very exactly in position with the striæ, which is very remarkable; but, in some of the deeply coloured scales there is a granulated appearance covering the entire surface of the scale very uniformly, in which the constricted appearance of the striæ is even more apparent. Hence it would appear that the peculiarity in the markings of the *Amathusia Horsfieldii* is due, not to their consisting of minute scales, but to the superposition of pigment-cells exactly over the beaded striæ; the transverse markings exhibiting the appearance most strongly. I do not see that there is anything in this assertion which is antagonistic to Mr. Bowerbank's view of the structure of similar scales; for though he did not remark that any of the striæ were constricted, yet that they may be so, and still be tubular, is evident; indeed, as regards the number of layers and general structure of the scales of *Lepidoptera*, my experience agrees fully with his view. The number of beads in the cross striæ of the *Amathusia* are from two to four; they are not globular, but,

on the contrary, vary much in their shape, and are connected together by a broad neck. The pigment-cells at the upper focus, present the appearance of a sort of irregular net-like covering to the upper membrane of the scale; this is lost sight of as we focus downwards, when the beaded striæ come into view. The distance of the longitudinal striæ of the scale, shown in Plate IX., is from a ten-thousand-five-hundredth to a six-thousandth of an inch, and that of the cross striæ from a twenty-thousandth to a ten-thousandth of an inch.

In conclusion I would remark that the crumpled structure of the striæ on the scales of the *Lepidoptera* has long been familiar to me; and since studying those of the *Amathusia Horsfieldii*, I have again examined several, and found the characters now described common, in degree, to a great number; they are, however, developed in a remarkable manner in those of the insect now under consideration.

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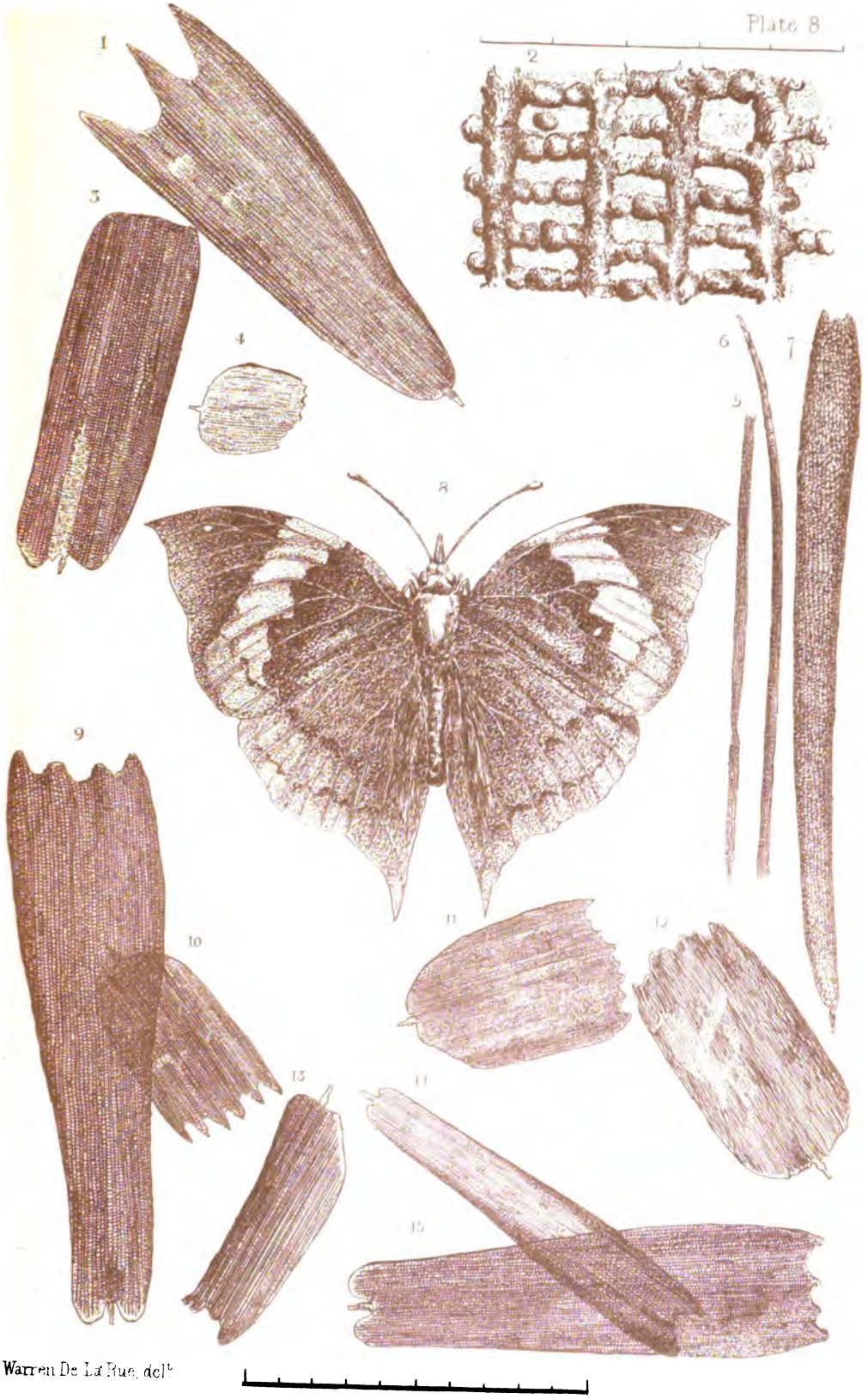
## EXPLANATION OF PLATE VIII.

Fig. 1. Scale from under side of upper wing of *Amathusia Horsfieldii*.
Fig. 2. Portion of a scale magnified 1900 diameters.
Figs. 3 and 4. Scales from under surface of upper wing.
Figs. 5, 6 and 7. Hairs of *A. Horsfieldii*.
Fig. 8. *Amathusia Horsfieldii*. Male.
Figs. 9 and 10. Scales from under side of tip of upper wing.
Figs. 11, 12, 14 and 15. Scales from upper side of tip of upper wing.
Fig. 13. Scale from under side of tip of upper wing.

## EXPLANATION OF PLATE IX.

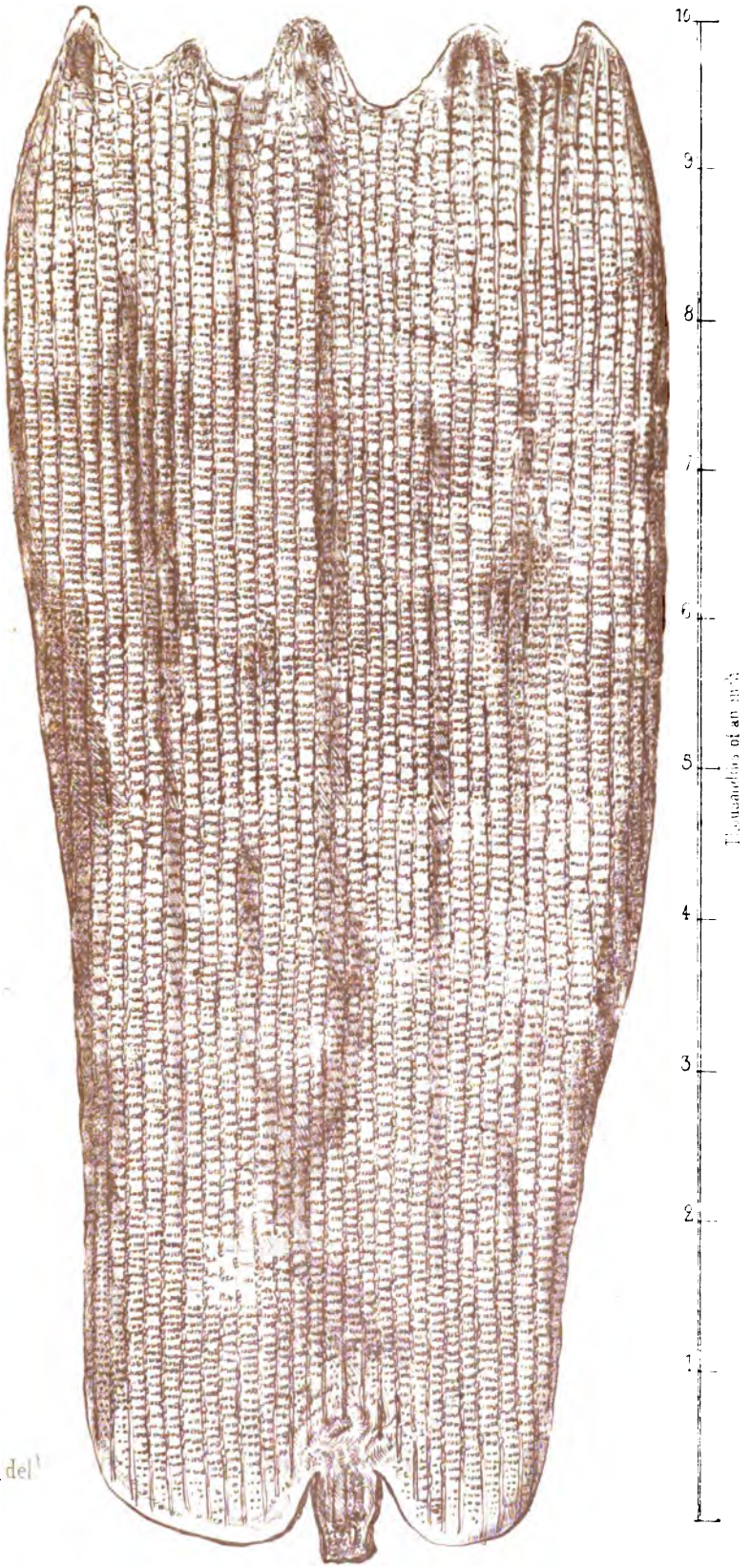
Characteristic scale of *A. Horsfieldii*, magnified 825 diameters.

Plate 8




Warren De La Rue, del.

8⅞ dia$^{s}$



Warren De La Rue, del$^{t}$

## VII. — *A Description of a new form of Hair from a species of Tarantula.* By George Shadbolt, Esq.

(Read April 25th, 1849.)

In examining the hairs and other cuticular appendages of animals, we cannot fail to be struck with the beauty and variety of the forms disclosed by the aid of the microscope; and as it is to be presumed that every modification of form and structure is intended to serve some particular end, it would be a highly interesting study, to endeavour to trace out the purpose for which each variation in these appendages is designed. In order to attain this end, it is advisable to collect as many facts relating to the subject as possible, for the purpose of comparison, and it is much to be regretted that so few have been placed upon record.

For such as we *are* acquainted with, we are chiefly indebted to the researches of our worthy president (Mr. Busk), and secretary (Mr. Quekett); and as regards that branch relating to the scales of butterflies, &c., we have recently been favoured with a highly interesting paper by Mr. De la Rue: but there are doubtless many points of interest connected with this very extensive class of objects, which are known to individual observers, but which, for want of being communicated otherwise than by mere conversational remark, are lost to all but the immediate parties concerned; and thus, those who might otherwise be desirous and able to consider this subject as a whole, are deterred from doing so, it being almost impossible for *one* observer to make researches into every branch of it.

In offering this paper to the Society, I do so chiefly with a view of inducing others, acquainted with any facts relating to hairs in general, to communicate them in a written form; for as our president truly remarked in his address on the occasion of our anniversary meeting, no *facts*, however trivial they may individually appear, are unworthy of being recorded, as in the aggregate they become of considerable value. It is simply with the purpose of aiding in carrying out this object, that I offer these remarks, and my communication is nothing

more than the description of what I believe to be some forms of hair not hitherto noticed.

The specimen, from which the hairs I am about to describe were taken, is one of the *Tarantulidæ*, and was brought to me for examination by my friend, Mr. G. E. Newth (a member of the medical profession), in whose possession it has been for several years. It was originally found alive amongst some logwood, from what precise locality I am unable to learn; it is, however, unquestionably a native of the tropical parts of the western hemisphere.

The animal is entirely covered with short, closely set hairs, so as to appear as if formed of velvet, of a dark brown colour, except the abdominal portion, which is of a dark red tint, and interspersed pretty numerously amongst the short hairs are some longer ones, of a light brown.

On examining these various hairs with a good quarter-inch object-glass, they are seen to be of a very compound character; those from the thorax or limbs of the animal, as shown in Plate X. fig. 1, consisting of a central shaft, most probably cylindrical, around which are disposed an immense number of small hairlets, generally covering the whole length of the hair, so as to make it resemble in appearance a mouse's tail or a lady's boa. The small hairlets are arranged in longitudinal rows, but whether in their transverse direction the points of attachment are in whorls, or alternate, or spiral, I have not been able to determine.

The longer hairs appear to be of a precisely similar character to the above, but of larger diameter and with a greater number of hairlets, and both kinds appear to have either a central cavity, or at any rate a structure admitting of the passage of fluid. I am also disposed to think, that the number of longitudinal rows of hairlets on each of the smaller hairs, is four, but of this point I am not yet quite certain.

I stated previously, that the dorsal part of the abdomen is of a dark red colour: the hairs from this part are also of a very compound character, which for peculiarity of conformation I have never seen surpassed, even by the scaly hairs of the Indian bat, or the arrow-headed variety from the larva of the *Dermestes*. They are perhaps more like feathers than hairs, and consist, as shown in Plate X. fig. 2, of a central shaft, formed somewhat like a flattened cylinder, tapering to a point at the base where it is inserted into the cuticle. This basal portion, consisting of about one-sixth part of the total length of

the hair, has some slight lateral appendages in the form of very obtuse pointed projections, so as to give that part a somewhat crenated appearance at the edge. On viewing these edgewise, they are seen to be confined to the thinnest edges of the flattened cylindrical shaft. From the point where these slight projections terminate, to about five-eighths of the length of the hair from the base towards the other extremity, there are also attached to the shaft, in the same plane with the projections just described, a number of flattened blades, having their free ends pointed, something in the form of a lancet. These incline at an acute angle with the shaft, the points being towards the terminal extremity of the hair, and there are about sixteen or seventeen of these blades on each edge of the central shaft. There is an internal passage up the shaft, and I am pretty certain that it extends also up the blades. Beyond these sixteen or seventeen blades the shaft is continued for the remaining three-eighths of the length, but instead of being smooth on the broader surfaces as hitherto, it is covered by a considerable number of slightly elevated, obtusely pointed projections, having their apices turned towards the base of the hair. The most remarkable feature, however, is, that within a short space of the termination of each hair, there are on each side of the central shaft, six more blades, each formed like those at the lower part as regards their sectional shape, and lancet-like point, and they are also in the same plane with them, but these latter six pairs of blades are curved and point towards the base of the hair, that is in a reverse direction to the others, and thus appear like so many barbs. Those nearest the end of the hair are somewhat longer than the others, so that the whole twelve together have an oval-formed outline. There is a slight projection beyond the last pair of blades, as if the shaft were continued a slight distance beyond them.

All the dark red hairs on the dorsal part of the abdomen appear to be of this remarkable construction, and it is the only part of the animal on which I have found this last described form; the other parts being all covered with those previously adverted to.

Now the brown hairs seem, from their construction, to be beautifully adapted for preventing the sudden alteration of temperature affecting the parts protected by them, and also for opposing the access of parasitic enemies from without, in consequence of the compact manner in which they fit together, and the peculiar arrangement of the small hairlets, and it is therefore probable they

may answer one or both of these purposes; but with regard to the red hairs, which I last described, I am totally at a loss to conjecture a probable purpose they may be designed to serve, and I shall be glad to hear any suggestions on the point.

Both kinds of the shorter hairs are from the tenth to the eighth of an inch in length.

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## EXPLANATION OF PLATE X.

Fig. 1. Hair from the upper surface of the body of a *Tarantula.*
Fig. 2. Hair from the under surface of the body of the same *Tarantula.*

Fig. 3 50 dia.s

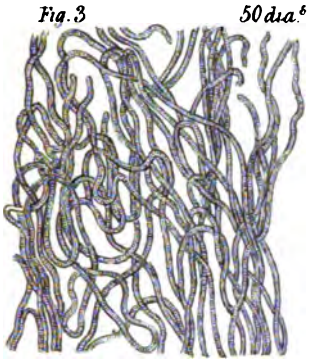

Fig. 4. 500 dia.s

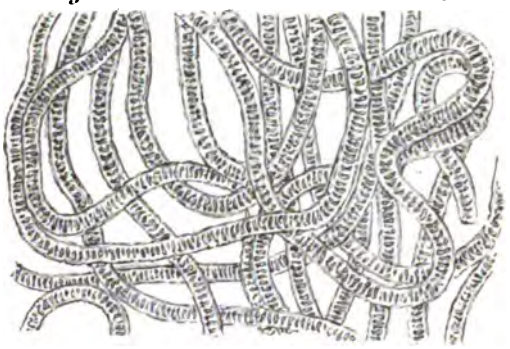

Fig. 5. 50 dia.s

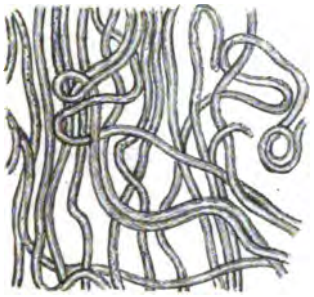

Fig. 6. 500 dia.s

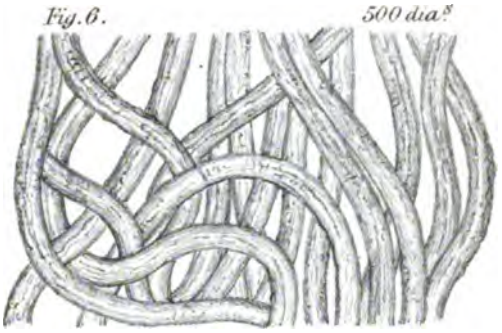

Fig. 7. 50 dia.s

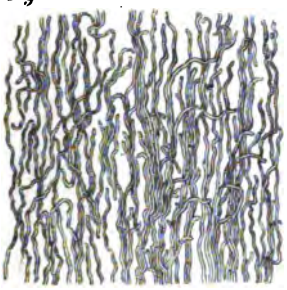

Fig. 8. 500 dia.s

Fig. 1.

Fig. 2.

S.W. Leonard, del et lith.

Day & Son Lith.rs to the Queen

## EXPLANATION OF PLATE X.

Fig. 3. Yellow fibres from the outer surface of the *ligamentum nuchæ* of the giraffe, showing transverse striæ.

Fig. 4. A portion of the same more highly magnified, showing the true shape of the striæ, and the fact of their not extending across the entire diameter of the fibres.

Fig. 5. Yellow fibres from the interior of the *ligamentum nuchæ* of the giraffe, showing the absence of the striæ.

Fig. 6. A portion of the same more highly magnified, showing faint indications of the central linear stripe.

Fig. 7. Yellow fibres from the *ligamentum nuchæ* of the sheep.

Fig. 8. A portion of the same more highly magnified.

## IX.—*On the Structure of the Siliceous Loricæ of the genus Arachnoidiscus.* By GEORGE SHADBOLT, Esq.

(Read November 14, 1849).

THE name *Arachnoidiscus* (appropriately chosen from the resemblance borne by the markings on these shells to the disposition of the filaments in a spider's web) was conferred on the genus by Mr. Henry Deane, the first observer who discovered entire specimens of it. Single valves had, however, been previously met with by Mr. Topping, Mr. Deane, and also by myself, amongst the siliceous remains of infusorial animalcules from the Ichaboe guano, but only very sparingly scattered.

In a paper read by Mr. Deane, at one of the meetings of this Society, he mentions having met with entire specimens of the *Arachnoidiscus* on some sea-weed from Japan, the sea-weed having been prepared or preserved as an article of food; and I understand he has since met with them on another marine Alga from a different locality.

Mr. Marshall has, at least, one very beautiful species, which, I believe, he obtained from Professor Bailey, of New York; and about two years back I had given me, amongst other things, some Algæ brought by Mr. Moxhay from the Cape of Good Hope, having attached to one of the specimens an immense number of individuals of this genus; hence it would appear that they are pretty generally distributed about the globe, having been obtained from five different localities lying so widely apart. The examination of these minute organic bodies excites in the mind a high degree of interest, not only from the exquisite beauty of the objects themselves, but also from their relation to the fossil siliceous remains met with in all parts of the world, sometimes in immense numbers, and in such infinite variety of form. As some highly interesting and ingenious suggestions have been promulgated respecting the former condition of the strata, whence some of the fossil organic bodies have been obtained, it appears to me, that the investigation of the *structure* of this class of objects, whether fossil or recent, would tend to further the

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deduction of still more important hypotheses. It is evident that for the purpose of examining into the structure, recent specimens are far superior to fossil ones.

Having repeatedly and carefully examined the structure of the shells of the *Arachnoidisci* in various ways, I purpose detailing a statement of the result of my investigations, particularly as in some few points I differ with the conclusions arrived at by other observers.

I trust that if the matter of this paper should be deemed uninteresting, I may be pardoned, from its being the means of placing in the Society's possession the accompanying very beautiful drawing, most accurately executed by Mr. Legg, who kindly undertook to assist me by performing so difficult, but necessary, a part as the delineation of the objects to be described.

The following observations apply to the shells alone, and not to the animals inhabiting them (if animals they be), for although the specimens I submitted to examination were recent, they were not in my possession until they had been dried for some months.

These shells are not, strictly speaking, bivalves, although capable of being separated into two corresponding portions; but are more properly *multivalves*, each shell consisting of *two* discoid portions and *two* annular valves exactly similar respectively to one another.

Each of the discoid valves is also capable of a further separation into two circular, but dissimilar portions, which separation, however, is by no means easy of accomplishment, owing to the very fragile nature of the substance of the shell: in fact, I have only been able to effect this separation by accident, although this I have done sufficiently often to satisfy me that all the discoid valves are composed of the two portions adverted to, and this fact is capable of very distinct verification by another means to be presently described.

The two parts of the disks consist of, firstly, a very thin membrane, somewhat flexible and elastic, and capable of resisting the action of boiling nitric acid, and on this membrane are the characteristic spider's-web-like markings, which have given rise to the name of the genus. It is situated externally in both disks of each individual. Plate XI., fig. 1.

Secondly, each disk is composed of a siliceous frame-work, admirably adapted to support and strengthen the outer membrane, and bears a very close resemblance to a circular Gothic window. Plate XI., fig. 2.

Each of these portions I have been able to obtain separately, by

boiling the disks for a considerable time in nitric acid, and then carefully washing with distilled water, but it is only here and there that the separation is effected, and still less frequently that the siliceous frame-work is obtained entire; but that each disk really consists of these two portions is easy demonstrable by the following mode of manipulation. Select as large a disk as you can meet with, and with a very fine sable pencil place it on a convenient black ground, and place this under the microscope to be viewed as an opaque object. If a $\frac{1}{10}$th inch objective be used, a side light will answer very well. Now, on inspecting the disk thus placed, it will present to the eye the appearance of either the membrane (fig. 1), or the frame-work (fig. 2); and if it be removed from the stage, and carefully turned over by means of the sable pencil (which can readily be done if the specimen selected be of a tolerable size), it will then present the contrary appearance to that at first exhibited. That these two portions are really distinct, is also readily shown by focussing up and down, which will show each portion in a distinct plane.

As the method just described is only available for the larger specimens, and cannot be applied to mounted objects, I adopted the following manner of testing the same facts. Place a drop of water, containing a few of the disks, on a square of thin glass, such as is used to cover objects with, and when the water has evaporated, so as to leave the objects dry, they will adhere to the glass; it is then requisite to cover the objects with a similar piece of thin glass, and mount the whole in the manner devised by Mr. Gillet, that is, by attaching the two pieces of glass, with the object included, to a slip of wood or other material, having as large a hole in it as the size of the slide will allow. The slide is then to be placed on the stage of the microscope, and viewed as a *transparent object* with the *achromatic condenser* attached. Having selected any individual to examine, produce the smallest possible spot of light by adjusting the achromatic condenser, then turn back the body of the instrument, and with a fine camel's-hair pencil, with a little carmine or Indian ink, draw around the spot of light a light line, so as to insulate the particular individual selected. By varying the form of the insulating line, such as drawing a circle around one, a triangle, a square, or a diamond around others, several on the same slide can be particularised. The *achromatic condenser* is then to be removed, and the smallest of the dark wells put in its place. The lieberkuhn

must also be attached to the object-glass, and on examining as an opaque object any one of the disks, the slide can be turned over, and the same disk readily be recognised by means of the lines around it; and thus, however minute, both sides may be inspected.

In viewing these disks as transparent objects mounted in balsam, it is by no means easy to determine whether they have or have not a central aperture, and polarized light renders no assistance in doing so; but on mounting them as above described, or on a black disk, and viewing as opaque objects, it becomes indisputably evident that a central opening is present. When *in situ*, these openings are partially covered *internally* by a delicate cup-like process, so as to form a species of valve; hence, when the shells are attached to the Alga, and are viewed even as opaque objects previously to their undergoing any sort of manipulation, it is not satisfactorily shown that the apertures exist in every specimen. I consider it highly probable that at these openings the nutriment is taken in, and from the peculiar radiated arrangement of the siliceous parts immediately around them, it seems not improbable that the animals may be provided with organs somewhat resembling in arrangement the tentacula of *Madrepores*. This is supposing the objects to be of an animal nature, of which I confess I think there is very little doubt.

With regard to the two annular valves previously mentioned, they are situated between the two discoid ones, and thus the whole shell, when in its natural state, resembles, like those of some other genera, a circular snuff-box. These valves consist of a siliceous ring, within which (extending a slight distance towards the centre) is an annular membrane, and when *in situ* the valves are placed so that the membranes of each valve are in contact, and thus the space included between the two discoid valves is partially divided into two (not three) chambers. The membrane is so thin, that when mounted in balsam it is not visible; I have, however, been able to detect it upon one or two occasions, when it has got accidentally discoloured. It can, however, be readily seen by breaking away the upper valve from a specimen when attached to the Alga, and also when mounted between the two pieces of thin glass. Plate XI., fig. 3.

It is somewhat difficult to make out whether there are two, or only one, of these annular valves, when the shell is entire; they can, however, under favourable circumstances, be defined, even while attached to the Alga, but if this latter be soaked in water, a few of the shells can sometimes be removed entire, and by examining them between

two slips of glass, in some very fluid balsam, the portions can sometimes be separated while under the field of the microscope, by sliding one piece of glass over the other.

Now, with regard to the observations of others, connected with this genus. I am informed by Mr. Henry Deane, that he has reason to believe that some at least of the individuals are attached to the Alga by a short pedicle, and, I believe, he considers it to be of a siliceous nature.

In all the specimens I have examined I am satisfied there is no trace of such an appendage, but that they are all sessile, and the superior and inferior valves correspond exactly in all respects. I cannot but imagine, that the radiated structure of the central orifice must have deceived Mr. Deane, in this point, possibly in consequence of his not having viewed the valves, when detached from each other, as opaque objects.

I was informed by Mr. Marshall that he considered these shells were disposed one above another in a sort of column, in a similar manner to the shells of the *Gallionella*, but I have not been able to find a single instance in which they were so placed. I scarcely know that I am justified in recording this as Mr. Marshall's opinion, and I question much if he now holds it. I only mention it, as it brings me to the consideration of the mode of propagation, a point I have not been able to arrive at. I have generally found these shells scattered singly all over the Alga, but in one or two instances I fancied I met with them double (that is, one on the other), or progressing towards that state. It is not improbable that the membranes named as attached to the two annular valves may, possibly, be extended and developed into valves similar to the discoid ones, and thus propagation may be performed by self-division, as in many of its congeners.

There is one consideration unfavourable to this view, as also to that at first adverted to, namely, that they are found of all imaginable diameters from ·004 to ·014 of an inch, scarcely any two being precisely the same, though if the method of propagation above mentioned were correct one would expect to find many in the same spot alike.

Another objection to this suggestion is, that the number of rays in each individual is by no means constant, and in some of the specimens there is, in one of the segments formed by the rays, an evident tendency to divide, the rudiments of a new ray being very

perceptible; this appearance is by no means unfrequent, as scarcely any slide I have mounted is deficient in furnishing one or more such facts.

I must not omit to mention, that I discovered the fact of the central aperture being covered internally by a sort of membrane, in consequence of Mr. Legg having drawn my attention to an appearance presented by one shell mounted in balsam which he has, in which the membrane is present, but slipped a little from its place.

The various appearances described in the foregoing paper are accurately represented in the drawings, which, by the kindness of Mr. Legg, as I previously mentioned, I am enabled to lay before you.

The objects themselves I shall have the pleasure of presently exhibiting, and the accompanying slides I purpose depositing in the Society's cabinet.

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## DESCRIPTION OF PLATE XI.

Fig. 1. The external membrane, as seen when detached from the inner frame-work, or when viewed from the outside of the shell as an opaque object.

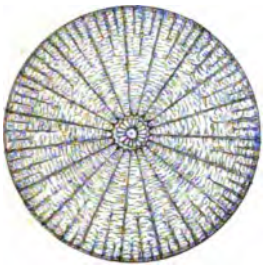
Fig. 2. The inner frame-work as exhibited on a black disk as an opaque object.

Fig. 3. One of the two annular valves.

Fig. 4. The membrane and frame-work united, as seen by transmitted light; 200 linear.

Fig. 5. The same, more amplified; 500 linear.

Fig. 1



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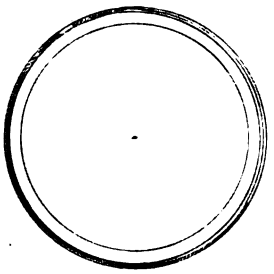

2

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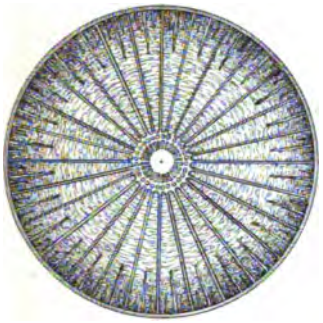

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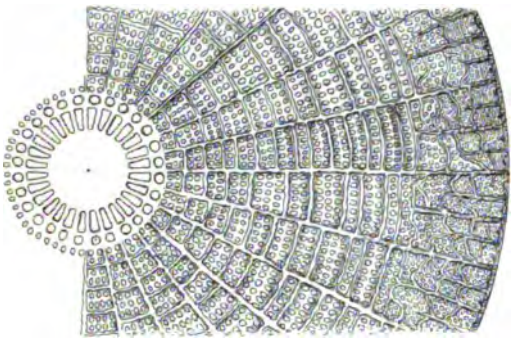

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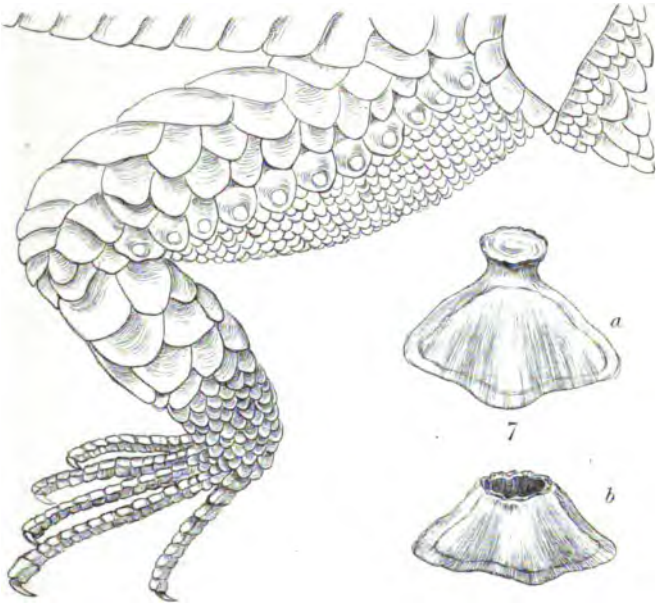

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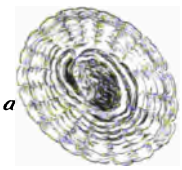

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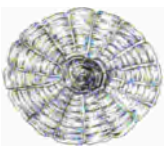

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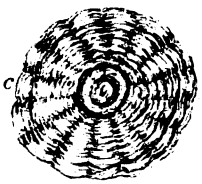

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a

b



E. W. Leonard. lith

Day, Son & Hodges, lith. to the Queen.

## X.—*Microscopical Observations on a Malady affecting the Common House-Fly.* By Cornelius Varley, Esq.

(Read November 14, 1849.)

The common house-fly is frequently seen dead and attached by the trunk to the glass of windows, and other places, the glass being rendered dim by a kind of white matter, which appears to be exuded from the body of the fly. This appearance having excited my curiosity, I was induced to turn my attention to the subject, with a view to discover its cause, and I now take an opportunity of laying the result of my observations before the Society.

This dimness appears to be the result of a peculiar disease affecting the fly, which manifests itself in the proboscis, the end of which becomes charged with a viscid exudation, and upon the application of the trunk to the glass of windows, &c., it adheres; death soon follows, and the misty appearance is produced in the course of a few hours, the body of the fly being always found suspended by the end of the proboscis (Plate XIII., fig. 1, *a*).

In order to obtain a knowledge of the progress of this disease from its earliest appearance, I cleared the windows, of one of my rooms, of all flies in the state I have described, and setting my children to watch, desired them to give me immediate notice of any flies that might become thus attached. As soon as this occurred, I removed them from the glass, placed them under the microscope, and commenced observing attentively such changes as might take place. For nearly half an hour there was no alteration; but after that time, some of the divisions between the scales of the abdomen began to appear white, as at *k k*, fig. 1. This went on until the whole of these divisions put on the same appearance. In some parts this white matter was produced in such abundance as to meet that from another division across the scales. In its earliest stage it appeared to be composed of myriads of round-ended cylinders, like *b b*, fig. 2; after a short time

these became elongated, and put on the appearance given in *c c c*. Their tops now began to enlarge as in *d*, and gradually assumed the form *e e*. There were two divisions in these elongated cylinders, the one across the neck, *g*, and the other lower down at *h*, the cell between these divisions, *g* and *h*, being filled with granular matter. As soon as they had assumed their complete form, circulation commenced in an oblique direction round the head. It gradually quickened, and the heads were finally driven off with violence by the bursting of the middle cell, *g h*, and were projected in every direction. They adhered strongly to whatever they touched, being surrounded with a viscid gummy matter from the bursten cell, as in fig. 3, and it is to their agency that the frosted appearance of the glass is due. Thus so many were driven off against the object-glass as to render it quite dim: I accordingly cleansed them off, and interposed a piece of thin glass to receive them, and thus enable me to ascertain their nature and form.

In fig. 4, I have represented one of these heads, with a portion of the bursten cell. Fig. 5, gives their size, being about $\frac{1}{1500}$th of an inch; *i i*, represents the misty appearance produced by their agency.

This disease is remarkably rapid in its development, for the whole time that elapsed from the death of the fly to the ripening and projection of the heads was not more than three hours.

The heads being always driven off whole, as in fig. 3, would lead us to suppose that they were seed-vessels, but I can give no opinion as to whether the disease is propagated from them or from the disrupted cells.

I do not believe this to be any casual or accidental mildew consequent on a disease, but the disease itself, for it always puts on the same appearance, and as it always commences in the proboscis, and as the death of the fly occurs before there is any appearance of the growth of these white cylinders, we may infer that the matter by which they are produced is highly poisonous.

Having thus satisfied myself as to the usual progress of this disease, I tried an experiment with these cylinders: I put some of the flies, in which this appearance had commenced, under water. In this case a considerable alteration took place, the cylinders no longer producing heads as before, but growing thin and crooked, like fig. 6.

It appears to me that the most useful practical inference that arises out of this investigation, is an inquiry how far human beings are subject to diseases produced by similar causes; and we may also ask, may not some of those diseases which attack people very suddenly, and without any appreciable cause, be occasioned by something similar to that which produces this disease in flies, the extraordinary minuteness of the germs causing such maladies occasioning them to elude our keenest observation?

## XI.—*On the Architectural Instincts of Melicerta ringens, an Animal of the Class Rotifera.* By P. H. Gosse, Esq.

(Read January 16, 1850).

Among all the aspects in which we regard the inferior animals, perhaps there is not one more fascinating than that in which we see them reflecting, as in a mirror, those actions in man which are the result of reason or experience. The architectural instinct of animals, in particular, by which they are impelled to form structures for the protection of themselves or their progeny, affords some of the highest treats which the naturalist knows. We hear with curiosity that the man-like orangs of West Africa and of Borneo construct rude huts among the branches of trees, in which they dwell; and the elaborate masonry of the beaver has been a theme of admiration for ages. The nests of birds, the waxen cells of bees, and the papery edifices of wasps, render these the most interesting of animals, as exhibiting in beautiful prominence parental foresight and care, as well as constructive skill. But there is another class of animal structures of so ambiguous a character that we scarcely know how to name them; we are in doubt whether the ingenious artificer should be denominated a mason or a tailor; whether he has made a house or a garment. I will not speak of the investing shell of the snail, or the valves of the oyster, nor yet of the tubes of the beautiful organ-pipe coral (*Tubipora musica*), for these are deposited secretions rather than constructions. The larvæ of the clothes-moths (*Tineadæ*), however, cut off the fibres of our textile fabrics, and weave them into a case of cloth; the caddis-worms, so familiar to anglers (the larvæ of the *Phryganeadæ*), collect little stones, shells and other extraneous bodies lying at the bottoms of streams, and, fixing them with a glutinous fluid from their mouths, form them into curious cylindrical cases; and I have, in America, seen the caterpillar of a moth (of the genus *Oiketicus*), which cuts off the slender stems of plants and the foot-stalks of leaves, and, dividing them into short lengths, builds up piecemeal, by the aid of its silk, a tube, around its body. These edifices all serve their owners for tents, into which they can retire, or which they can leave at will; while by the nature of their lining,

and by the closeness of their investiture, they may be considered as clothing.

The subject of the present paper is of this class of animal artificers. It is an animalcule, so minute as to be with difficulty appreciable by the naked eye, inhabiting a tube composed of pellets, which it forms and lays one by one. It is a mason, who not only builds up his mansion, brick by brick, but makes his bricks as he goes on, from substances which he collects around him, shaping them in a mould which he carries upon his body.

Neither the animal itself nor its architectural habit is any new discovery; both the one and the other were made known at a very early period in microscopical science. The illustrious Leeuwenhoek discovered the species at Delft, in 1703, and described its appearance and manners in the Phil. Trans. (v. 176, abridged edition). It was afterwards noticed by many observers; until, at length, in the magnificent work of Prof. Ehrenberg, its past history was detailed, and enriched by the addition of his own most admirable observations.

As, however, my own observations on this animal were made before I had seen those of either of these illustrious microscopists, and as, in the most interesting part of its economy, they disagree with the conclusions of the latter, and add something to those of the former, I shall commence with a brief description from my own notes.

Attached to the roots of *Lemna*, or the narrow leaves of *Chara*, *Nitella*, *Ceratophyllum*, and other sub-aquatic plants, may often be observed a tube, a little wider at the top than at the bottom (Plate XII., fig. 4). It stands erect, being fixed by the base, which is sometimes dilated; the mouth being uppermost. This tube is of a dark yellowish or reddish brown hue, and is found to be composed of a multitude of round pellets, set very regularly in a sort of mosaic, apparently agglutinated by a cement insoluble in water. The upper part or rim, is usually irregular, as if broken off with a ragged edge (fig. 2, *a*).

But while we gaze, a curious object is slowly protruding from this tube. A complicated mass of transparent flesh appears, involved in many folds, displaying at one side a pair of hooked spines (fig. 2, *b*), and at the other, two slender truncate processes, projecting horizontally (fig. 2, *c*). As it exposes itself more and more, suddenly two large rounded disks are expanded, around which, at the same instant, a wreath of cilia is seen performing its surprising motions (fig. 4, *d*). Often the animal contents itself with this degree of exposure, but sometimes it protrudes farther, and displays two other smaller leaflets opposite to the former, but in the same plane, margined with

cilia in like manner (fig. 1, *e*, *e*). The appearance is now not unlike that of a flower of four unequal petals; from which resemblance, Linnæus, who compared it to a ringent, labiate corolla, gave it the trivial name *ringens*, by which it is still known. On each petal we see a white line, probably a nervous thread, running parallel with the margin, to which many short lines radiate from it.

But the eye is involuntarily drawn from the petals themselves of this living flower, to the beauty of the coursing cilia (fig. 1, *f*, *f*): these appear to chase each other in ceaseless race along the margin, running down and up the sinuous divisions of the petals, now relaxing, now refreshing, their speed. This progression of the ciliary waves is now explained; but while we gaze upon them, we find it easy to forgive the error of Colombo and Dutrochet, who maintained that the teeth actually ran around the margin of the stationary wheel. There is a remarkable phenomenon in the ciliary course in this genus, which I have observed also to characterize *Limnias*, *Megalotrocha*, and a species which has occurred to me, belonging to an undescribed genus; but which does not occur to nearly the same extent in the *Rotifera* generally. Each cilium appears thickened in one or two places in a very regular manner, forming thick black spots, which run along the course, and produce a very striking effect. I conjecture that each cilium is alternately either dilated and attenuated, or else bent nearly in the line of vision at these points (so as to appear thick by perspective), and straightened, in rapid succession.

Below the large petals on the ventral aspect, and just above the level of the projecting respiratory tubes, is a small circular disk, or aperture, within the margin of which a rapid rotation goes on (fig. 1, *g*). This little organ, which seems to have hitherto escaped observation, I can compare to nothing so well as to one of these little circular ventilators, which we sometimes see in one of the upper panes of a kitchen-window, running round and round, for the cure of smoky chimneys.

The gizzard, or muscular bulb of the œsophagus (fig. 1, *h*), is always very distinct, and its structure is readily demonstrated. It consists of two sub-hemispherical portions, or jaws, each of which is crossed by three developed teeth, which are succeeded by three or four parallel lines, as if new teeth might grow from thence. The teeth are straight, slender, swelling towards their extremity, and pointed. These armed hemispheres work on each other, and on a V-shaped, or tabuliform apparatus beneath, common to most of the *Rotifera*, but in this genus very small.

Below the gizzard are seen several sub-globose sacculate viscera, which the opacity of the case forbids to trace down; they are doubtless the commencement of a constricted stomach, with its accessory basal vesicles (pancreatic or biliary?); as I have traced the passage of coloured food through them (as far as the margin of the tube permitted vision), in the form of a constricted canal. On one occasion, the accidental desertion of its case by an individual enabled me to submit the latter to compression, and to discover that the anal orifice is situated near the middle of the body, on that side on which the little curved horns (fig. 2, *b*) are placed, and consequently opposite to that which is furnished with the respiratory tubes (*e*) and the little rotating organ (fig. 1, *g*). The pellets composing the case are very regular in form and position; in a fine specimen (about $\frac{1}{28}$ inch in length when fully expanded, of which the tube was $\frac{1}{36}$ inch) I could count about fifteen longitudinal rows of pellets at one view, which might give about thirty-two or thirty-four rows in all.

Such was the amount of my acquaintance with this beautiful form, on the 17th of November last. On that day a fine specimen fell under my observation, attached to a submerged moss, from a pond at Hackney. I had the great pleasure of seeing this individual engaged in the building of its case, and at the same time of discovering the use of the curious little rotatory organ on the neck. When fully expanded, the head is bent back at nearly a right angle to the body, so that the disk is placed nearly perpendicularly, instead of horizontally; the larger petals, which are the frontal ones, being above the smaller pair.* Now below the large petals (that is, on the ventral side), as in *Limnias* (fig. 3), &c., there is a projecting angular chin (*i*), which is ciliated, and immediately below this, in *Melicerta*, is the little organ in question (fig. 1, *g*). It appears to form a small hemispherical cup, and is capable of some degree of projection, as if on a short pedicle. On my mixing carmine with the water, the course of the ciliary current was readily traced, and formed a fine spectacle. The particles are hurled round the margin of the disk, until they pass off in front through the great sinus (fig. 1, *j*), between the larger petals. If the pigment be abundant, the cloudy torrent for the most part rushes off, and prevents our seeing what takes place; but if the atoms be few, we see them swiftly glide along the facial surface (fig. 3, *k*), following the irregularities of outline with beautiful precision, dash round the

* I made no drawing of *Melicerta* in this position, but the figure of *Limnias* is sufficiently like to illustrate the peculiarity spoken of.

projecting chin (*i*), like a fleet of boats doubling a bold headland, and lodge themselves one after another in the little cup-like receptacle beneath. The action of the cilia which perform this transport is clearly seen; and I believe that they are continuous from the great sinus to the cup. The contents of the cup are whirled round with great rapidity, and it was while looking at this spectacle, that the notion occurred to me, that the pellets of the case might be prepared in this receptacle. Dr. Mantell, in his interesting 'Thoughts on Animalcules' (p. 60), had informed us that the pellets are coloured with admixed pigment; but he supposed with Dr. Ehrenberg, whose observations I shall presently quote, that they were expelled from the orifice of the rectum.

I now watched the animal with eager expectation, and presently had the satisfaction of seeing it bend forward its head as I had expected, and after a second or two raise it again, when I saw that the little cup had lost its contents. It immediately began to fill again; and when it was full, and the contents were consolidated by rotation, aided probably by the admixture of a salivary secretion, it was again bent down to the margin of the case, and emptied of its pellet. This process I saw repeated many times in succession, until a goodly array of dark red pellets were laid upon the yellowish brown ones, but very irregularly. After a certain number were deposited in one part, the animal would suddenly turn itself round in its case, and deposit some in another part. It took from two and a half to three and a half minutes to make and deposit a pellet. Some atoms of the floating carmine now and then passed down the œsophagus into the gizzard, and thence into the stomach; but these were quite independent of, and unconnected with, the pellets, which were composed exclusively out of the torrent that had passed off the disk. On one occasion the cup was brought down to the margin, but, from some cause or other, failed to deposit its pellet: it was raised for a moment, and then a second attempt was made, which was successful.

Professor Ehrenberg, however, thus speaks of the phenomenon in question:—"According to my own observations, the tubes are composed of little lenticular bodies, which the animal (as Leeuwenhoek indistinctly saw, but I distinctly discovered) separates from the posterior intestinal orifice (*aus der hintern Darmündung*) and glues fast with the same. Therefore the tube is always of the same height as this part of the animal. These granules are not extraneous bodies, like those on the tube of *Phryganea*, nor are they excrement; but a

peculiar gummy substance, which hardens in water, mingled, however, with the latter."—('Die Infusions-thierchen,' p. 406.)

I know not what to think of this discrepancy. It is scarcely possible that the experience and power of observation of so excellent a naturalist could have been at fault in a matter, which he himself says he distinctly saw; and his general care and accuracy forbid us to doubt that what he saw he has correctly recorded. Are there then two modes of effecting the same object in the same animal? This is scarcely imaginable. Or, are there two species, closely allied, but differing in this part of their organization and economy? From one or two other slight differences which I have observed, this may be just possible: at any rate it should be borne in mind in future observations.

The venerable Leeuwenhoek thus describes what he saw, which seems to me sufficiently distinct. "I viewed one of these animals a good while together, and observed several times, one after another, that when the animalculum thrust out its body from the sheath or case, and that the wheel-like or indented particles moved in a circle, at the same time, out of a clear and transparent place, a little round particle appeared, which without nicely viewing could hardly be perceived; which particle growing larger, moved with great swiftness, as it were about its own axis, and continued without any alteration in its place, till the animal had drawn part of its body back into its sheath; in doing which it placed the said round particle on the edge of its sheath, which thus became augmented with a round globule; and whereas the animalculum had placed the said globule on the east part of its sheath, another time it fixed it on the south or north side; by which means the sheath was regularly increased on all sides."—Phil. Trans. iv. 43 (abridged edition).

I would again observe that I had not the slightest acquaintance with these observations, till some time after I had made the whole of my own; which were recorded with the animal before my eye.

## DESCRIPTIONS OF PLATE XII.

Fig. 1. *Melicerta ringens*, protruded and fully expanded; with the upper part of its tube. Magnified 300 diameters.

*c*. One of the respiratory (?) tubes.

*e e*. The occipital petals of the disk.

*f f*. The frontal petals.

*g*. The pellet-cup.

*h*. The gizzard and intestine, as these viscera appear after the animal has been fed upon carmine.

*j*. The frontal sinus.

Fig. 2. The same unexpanded, viewed laterally. Magnified 300 diameters.

*a*. The tube, formed of pellets.

*b*. The occipital spines.

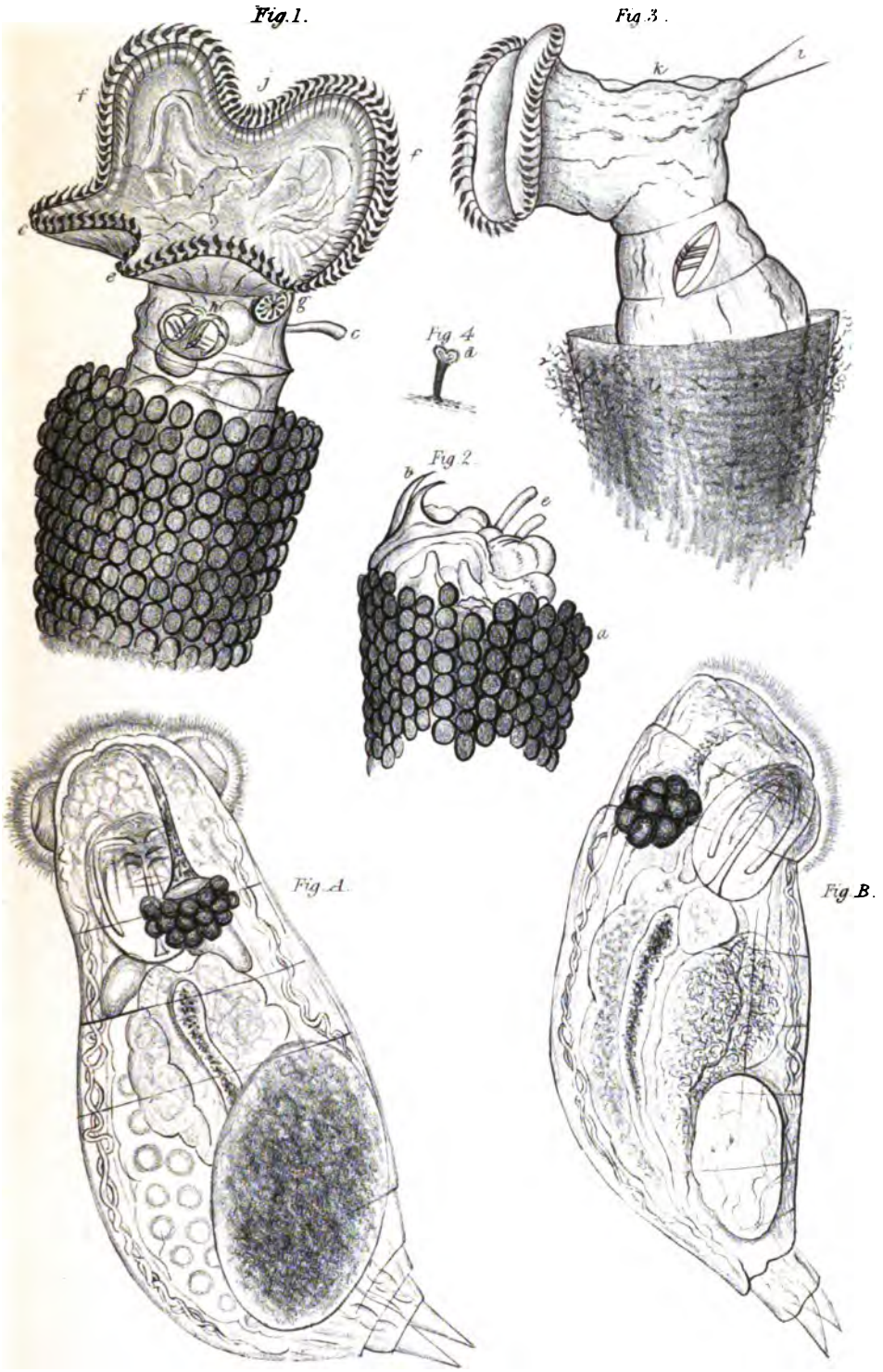
*e*. The respiratory (?) or antennal processes.

Fig. 3. *Limnias Ceratophylli* (magnified 300 diameters), introduced to show the form of

*i*. The projecting chin; and

*k*. The horizontal face.

Fig. 4. *Melicerta ringens*, partially expanded, viewed in front, with the whole tube shown. This is much less magnified. In the first three figures the lower part of the tube is not drawn.




P H Gosse del. S Leonard lith

Day & Son lith to the Queen

## XII.—*An account of the Dissection of a Human Embryo of about the Fourth Week of Gestation, with some Observations on the Early Development of the Human Heart.* By Arthur Farre, M.D., F.R.S., Professor of Midwifery in King's College, &c.

(Read March 19th, 1850.)

There is, perhaps, no department of physiology, which so much needs a careful and accurate record of the various facts and observations which time and opportunity afford, as that relating to human embryology. Numerous as have been the investigations carried on of late years into the wonderful and complex processes of reproduction, there is still no one stage of it which can be said to be yet thoroughly explored; and certainly in no case is the path of observation beset with greater difficulties, than in the effort to carry out a connected series of observations on the early development of the human frame.

The causes of this difficulty in regard to man, as compared with other animals, are so obvious, that to enter upon a consideration of them here would be quite superfluous. But I may observe that independent of the comparative rarity of the opportunities afforded, and the impossibility of learning from experiment in the human subject, while in animals our occasions may be as numerous and diversified as we choose to make them; there are added in our own species these further difficulties, that the ova or embryos discharged in abortion are most frequently malformed (malformation being a very common cause of abortion); that even the comparatively few specimens which are not malformed, are still generally broken and destroyed by the action of the uterus on their tender structure, during the process of expulsion; while, lastly, if the specimen has escaped this ordeal, it is too often injured by the rough handling of curious observers before it comes into our hands.

I trust, therefore, the Society will partake in the interest which I feel, in having just now one of these opportunities of examining the conformation of the human embryo, at almost the earliest period at which the microscope can be employed in the investigation of its

structures. And although in the brief account which I am about to offer, I do not pretend to any entirely new observations, I yet may claim for the subject this degree of importance, *viz.*, that in a matter of such great and acknowledged difficulty, and in one, moreover, in which imagination has been too often allowed to be the substitute for true observation in regard to many supposed facts, every addition that can be made to our knowledge though it do but serve to confirm already received doctrines, is valuable in itself on that account. Nor do I know any better channel for communicating such knowledge, and, if it be deemed worthy, of placing it on permanent record, and thus making it generally useful, than that which our Society affords.

The embryo which I am about to describe was expelled by abortion three days ago. No information which I can procure from the mother, affords any evidence as to the period of commencement of pregnancy, because the ordinary data from which such calculations are usually made, were not here present. No menstrual period having occurred since the 5th of November last (four months and a half from the present date). From the condition of the embryo, however, I deem it to be of the fourth week of utero-gestation.

The entire ovum weighed six drachms; it measured two inches in its longer, and one inch and a quarter in its shorter, diameter. All the membranes were entire and perfectly distinct from each other. The outermost or decidua vera exhibited the processes, termed by Dr. Mongomery decidual cotyledons, in an unusually well-marked degree. The cribriform markings on the inner or reverse surface of the same membrane were equally distinct. The only point of junction between this and the next membrane, or the decidua reflexa, was at that part of the ovum which had lain over the cervix uteri, and here it was reflected all round in a perfect circle on to the chorion, in order to form the decidua reflexa. This, I may observe, is not the most frequent point of reflection, which more commonly is found towards one or other Fallopian tube, and consequently at the upper part of the uterus.

The observation of this latter fact is not unimportant for two reasons. First, because it affords a probable explanation of the cause of the ovum becoming aborted, for at whatever point the decidua becomes reflected on to the ovum, there alone can the vessels which connect the latter with the uterus enter. This is consequently the most vascular part, the placenta is here formed, and if this more vascular portion be implanted over or near the os uteri, hœmorrhage is likely to occur, as in the present case; the loss of blood leading

to the subsequent expulsion of the entire ovum. But I notice this point here more particularly, because, though interesting in a practical point of view, as showing how slight a circumstance, such as the mere accidental point of reflection of a membrane, may in the progress of the case lead to serious or even fatal hœmorrhage, there is yet this important inference fairly deducible from it, namely, that if we can discover any accidental or obvious cause of abortion, which is referrible to the condition of the mother, we need not in such cases infer that any arrest of development of the embryo was the occasion of its being expelled, and consequently we may look upon ova so expelled as healthy, and may regard them as affording good subjects for observation. Such was the case in the present instance, and, therefore, whatever appearance the embryo now before us presents, these may be fairly regarded as exemplifying the normal conformation of an embryo of that period; and its organs, though exhibiting a condition of remarkable simplicity, may be inferred to be such as are capable of maintaining embryonic life at that early period, and such as would have sufficed for continued existence had not accident suddenly arrested their development. To such accident then, and to such causes, by which the most obscure of nature's processes are suddenly arrested in their course, and exposed to our view, are we mainly indebted for all that we can learn of this interesting subject.

Not to dwell unnecessarily upon the description of the membranes or investments of the embryo, I will only observe further, that the chorion was covered on the greater part of its surface with well-developed branched processes, the largest of which measured about one and a half line in length. By these, the outer membrane of the ovum was firmly attached to the decidua, and the process of formation of the placenta appeared to be thus already commencing. The intermediate space between these two membranes was filled by firmly coagulated blood, in which the chorion villi were deeply imbedded; and though this was, probably, an abnormal condition, and, perhaps, in some measure connected with the maternal hœmorrhage already mentioned, the notice of the fact of the presence of blood in this situation, in which it is abundantly found in a normal state at a subsequent period, namely, in the site of the placenta, ought not, I conceive, to be omitted. The mass of coagulated blood thus surrounding the chorion, measured, in different parts, from four to five lines in thickness.

Entirely free within this, and suspended by a cord of no appreciable length, was the delicate embryo completely surrounded by the

amnion. The latter, of the size and form of a small grape, was rendered quite tense by the liquor amnii, the transparency of its walls permitting an accurate view of the entire contents.

The embryo itself (Pl. XIII., fig. I.) measured four lines in length when fully extended, but in the curved form in which it lay when first examined its length was only three lines and a quarter. Its utmost weight, so far as I could estimate it, for it was impossible, without destroying it, to remove the embryo from the fluid in which it was examined, was one grain and a quarter.* Notwithstanding the extremely early period of development, many of the lineaments of the future being could be distinctly traced; the head (fig. II., 1), trunk (2), rudimentary anterior and posterior extremities (3 and 4), and some of the viscera, being clearly distinguishable.

The head (fig. II., 1) in this specimen bears a less proportion to the trunk than is observed in the second month of gestation. The three masses of nervous matter constituting the three pairs of ganglia for the corresponding sensual organs of smell, sight, and hearing, are here of nearly equal size. The division between these three pair of ganglia, the foundation of the future brain, is here very well seen in viewing the object by transmitted light, a slight depression at each point of junction also marking the divisions externally. The closest examination of the surface fails to detect any sign of organs of sense, but a very careful observation by transmitted light, with a good lens, discovers the eye (fig. II., 6), and ear (7) in process of formation; the earliest indications of these organs that I have yet seen. The absence of any external indication of the eye would alone serve to characterize the early stage of this embryo, since, even in the early part of the second month, this organ is conspicuous from the deposit of pigment within it, which is then generally found. Transmitted light, however, exhibits the mere outline of a slightly opaque, but well-marked circle, with a minute point in its centre on either side of the head, lying immediately beneath the second, or optic lobes, and just behind the first, or olfactory lobes, of the primitive cerebral mass.

A similar mode of examination detects another pair of minute bodies (7), representing the acoustic vesicle or primitive internal ears; between the second or optic, and the third or auditory lobes, or rather immediately beneath the latter.

* I estimated the weight by cutting a piece of the fibrinous clot before mentioned into the form and exact size of the embryo, and weighing this.

Thus the head consists of the three primitive pairs of cerebral ganglia, arranged in a triangular form with the traces of the organs of vision and hearing: the whole invested in a soft white integument.

Immediately below the head the trunk swells out into a gently curved line, in which are seen by transmitted light, the parallel lines (fig. II., 2), at regular and short intervals, indicating the points of division of the primitive notocord, into the several sets of vertebræ. These transverse divisions are as yet equal throughout the whole length of this primitive spinal column, which, after curving somewhat abruptly forward at its extremity, ends in a narrow point or tail (5).

The little buds (3 and 4) which indicate the extremities are already conspicuous, projecting from either side of the trunk; the anterior pair, about one-third of a line in length, being more developed than the posterior pair. The latter are situated closely on either side of the pointed extremity of the trunk, which projects beyond them, and thus renders them less conspicuous than the upper pair.

The trunk, therefore, here consists of the curved and primitive spinal column, already showing the divisions or markings out of the vertebræ, together with the little buds indicating the upper and lower extremities. Posteriorly, and above and below, the trunk is gently bent upon itself, and presents everywhere a smooth and curved outline, being covered in all parts by integument of a white colour, but anteriorly the whole of the abdominal and thoracic cavities are perfectly open, these cavities being in fact not yet formed, or perhaps only so slightly protected by integument that the mere act of opening the sac of the amnion in which the fœtus lies, and with which its integument is closely connected, serves to break down any slight covering which the trunk might have already received in this situation.

In the present instance, the whole anterior part of the body is thus open, from the head to the point of origin of the umbilical vessels. The mouth is not yet formed, but a simple elongated opening, beneath the head, consisting of two parallel folds of integument, indicate the commencing formation of the naso-buccal fissure, which itself is again transformed into the nose and mouth at a still later period.

On either side of this anterior fold or aperture are two minute openings (fig. II., 8 and 9) in the neck, which may even be discovered

by the unassisted eye. These are evidently the remains of the so-called branchial openings or fissures, of which the upper pair (8) was probably destined to remain permanent, and to become the external meatus; the lower (9) would probably have soon been obliterated.

The only viscera which can be discovered are a small mass (10) on the right side, on a level with the anterior extremities, which is generally termed the hepatic mass, and indicates the future liver; and at the same height on the left side is seen a curved vessel or hollow organ (fig. III., 12, 13 and 14), divided into three parts, upon the use of which there can, I think, be little doubt. All analogy and all reasoning as to the organs which would be requisite to carry on life at this stage of embryo existence, would, I think, point to this as one connected with the circulation, the establishment of which is essential at this stage, rather than with digestion, for which there is no need. I shall, therefore, be justified in regarding this as the primitive condition of the heart, and shall presently revert to this part of the subject, for the purpose of contrasting the development of the organ at this period with two other examples, at a somewhat later stage.

With the exception of the organs just described, there appear to exist no others. A slight indication, however, of two linear-shaped bodies is discoverable along the back of the open abdominal cavity, and these, both on account of their situation and form, may be assumed to be the incipient Corpora Wolffiana, the transitional representatives of the future kidneys and testes or ovaria.

Lastly, immediately above the curved extremity of the trunk, the minute umbilical chord (15) is seen blending itself with the chorion, and surrounded by the amnion, but the course of the vessels could not be traced. There was no indication of the presence of either an umbilical vesicle or of an allantois in this embryo.

I have now only to offer a few observations on the development of the heart to which I have just adverted. I have described this organ, in the present case, as presenting the appearance of an elongated vessel curved upon itself and exhibiting three divisions or chambers, representing the single auricle (fig. IV., *a*), ventricle (*b*), and bulbus arteriosus (*c*), which compose the heart of the lowest class of vertebrate animals, or that of fishes. The two latter chambers have thick and fleshy former, the latter is thin and membranous; the whole constituting an organ closely resembling that which we observe as a

transitional stage of the heart in the early development of the chick, or the permanent stage in the class of animals just mentioned.

In order to carry out the analogy, and to endeavour to exhibit the successive stages of development of this important organ in the human embryo, I have inserted, in the illustrations which accompany this paper, two drawings, made also from dissections of my own, which represent the heart of the embryo at two periods a little in advance of the present case; the one (fig. V.) at the beginning, and the other (fig. VI.) at the end, of the second month, as far as the age could be estimated from the size and development of the fœtus.

The first figure (V.) represents the heart as composed now of two auricles (*a* and *b*) instead of one, but still having only one ventricle (*c*), thus symbolizing the heart of the class of vertebrate animals next in advance of fishes, namely reptiles, in which the organ is thus constituted.

Again, the second figure (VI), representing the heart of a fœtus at the end of two months, shows a still further advance, for now the ventricle (*c*) has become divided into two chambers, thus assuming the permanent character. The thin membranous, leaf-like auricles (*a* and *b*), however, still exhibit traces of a primitive stage of development, which character may also be traced in the yet unobliterated bulbus arteriosus.

In conclusion, I wish to be understood as having offered these and other observations contained in this brief account, as entirely open to revision and correction, should further investigations prove such to be required. For the reasons already specified, the opportunities of procuring perfect specimens for examination are so rare, that it is difficult to obtain corroborative evidence by contrasting specimens one with another in precisely the same stage of development. Hence, many observations so made, must, for a time at least, rest upon the evidence which a single specimen can afford: for neither is much help to be derived from many of the published descriptions (the authors often not agreeing in their accounts), nor are all the delineations of early ova which have been put forth free from the suspicion of some degree of imagination, at least, having been exercised in aid of these points, which imperfect instruments, or injured and imperfectly developed specimens, may have left obscure.

The only correction for these impediments to our advance in a knowledge of human embryology, is for every one who has the opportunity of making careful examination of perfect specimens, to

add his observations to the general stock of our knowledge, as time and chance may offer occasion. For if these are retained with the expectation that time and further opportunities will suffice to render them more perfect or complete, the experience of most of the members of this Society, will, I fear, agree with mine upon all such matters, namely, that the desired period of perfection or completion seldom or never arrives, or that the matter if too long delayed, has lost that freshness and interest which constitutes its greatest attraction when given fresh from the mind of the observer. I regard it as one of the peculiar excellencies of Societies like ours, that they afford the best possible means for conveying to the scientific world, those isolated observations and facts, which, if carefully made and authenticated, constitute the very best materials for our advancement in any department of natural knowledge. And I trust that the members will accept this brief memoir from me, on the first night of my coming into office as their President, as an earnest of the desire that I feel for the mutual improvement of our opportunities, and for the establishment of a more general desire to communicate, in the form of brief written records, those observations which our unrivalled opportunities, especially in regard to instruments of research, both individually and collectively, cannot fail to be constantly placing at the disposal of every one of us.

Fig. 1.

Fig. 2.

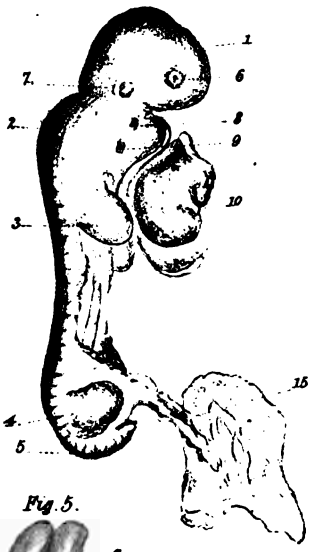



Fig. 3.

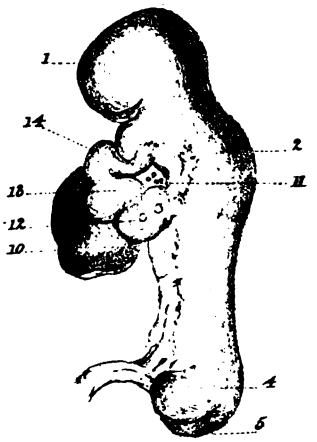



Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4.

Fig. 5.

Fig. 1.

Fig. 3.

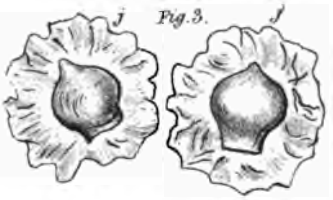



Fig. 6.

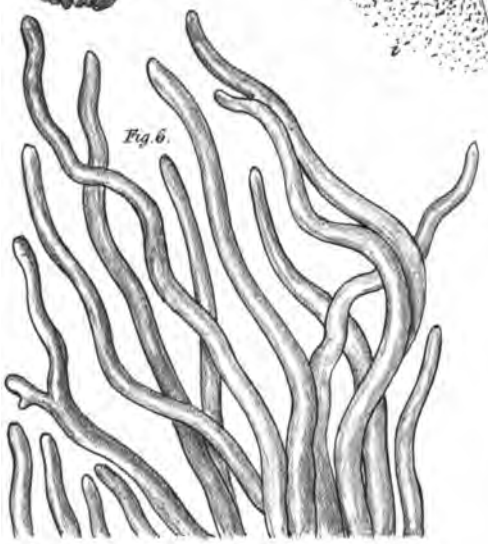
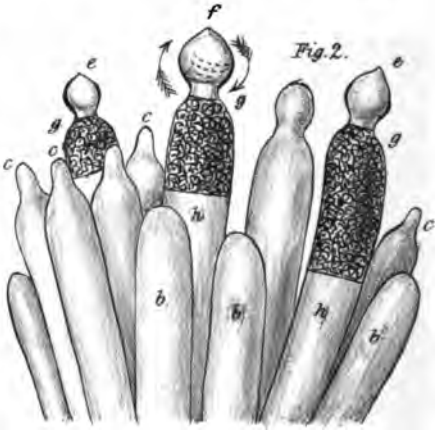


Fig. 2.




Observed & drawn by Cornelius Varley

Day & Son Lith.rs to The Queen

Figs 1 to 6 ..... (Human Embryo) are drawn by A Farre M D

## DESCRIPTION OF PLATE XIII.

Fig. I. Human embryo of about the fourth week, natural size.

Fig. II. Do., magnified five diameters. 1, head; 2, spine; 3, anterior extremity; 4, posterior do.; 5, coccyx; 6, rudimentary eye; 7, rudimentary ear; 8, external meatus; 10, hepatic mass.

*Note.*—This fig. is shown as under the combined effects of transmitted and reflected light.

Fig. III. Figs. up to 10, as in the former; 11, rudimentary pulmonic vesicles; 12, auricle; 13, ventricle; 14, bulbus arteriosus

*Note.*—This fig. is shown only as an opaque object. The internal ear and eye and the vertebral markings are consequently not seen.

Fig. IV. Heart detached; *a*, auricle; *b*, ventricle; *c*, bulbus arteriosus.

Fig. V. Heart of embryo at beginning of second month.

Fig. VI. Do., end of second month.

## XIII.—*A short Description of M. Nachet's Prisms, for the Oblique Illumination of Transparent Objects on the Stage of the Microscope, with Formulæ for their Construction and Observations on the their Use.* By GEORGE SHADBOLT, Esq.

(Read March 20, 1850).

THE use of some contrivance for causing the light to fall obliquely upon an object under examination, must be familiar to all microscopists who have been engaged in investigating the structure of such as have very minute and delicate markings, that are difficult to be defined; very slight eminences and depressions, as well as some other peculiarities of structure, being thus rendered more apparent from the increased contrast of light and shadow.

In order to render such a mode of illumination effective, it is, however, necessary that the rays of light should fall in some particular direction with respect to the object; and to accomplish this requisite with facility, a modification of the stage generally attached to our modern microscopes was arranged and carried out by Mr. Legg.

In the address delivered by our late respected President, Mr. Busk, at the anniversary meeting of this Society, in February last, he mentioned, when enumerating the additions to our means of investigation, the production, by M. Nachet, of Paris, of a prism for the purpose of effecting oblique illumination, which little instrument has also some advantages over the revolving stage. As I have found from practical experience that it is of very material assistance in investigating the structure of the class of objects above indicated, I have presumed to think that a short description of it, together with data for its construction, may not be without interest to some of our members.

The first instrument of this kind that I met with was shown to me by one of the members of this Society, Mr. Hodgson, who brought it over from Paris, and I afterwards saw some that Mr. De la Rue obtained from the same quarter.

The prism consists of a piece of glass with six faces, two only being parallel to one another, and these two sides are not polished, in order to prevent any reflection. The other four sides are inclined

to one another at various definite angles, the particulars of which I shall presently explain, so that the outline of the unpolished sides is of a trapezoid form.

To the smallest face of the prism (which should form a square) a plano-convex lens is cemented, and when in use it is through this lens that the light emerges from the prism, and is condensed in the focus of the lens, and immediately upon the object under examination.

This will be more readily understood by reference to the figures.

Fig. 1 represents the side view of a prism, without the lens, which must be attached to the surface, *d q*.

Fig. 2 represents an enlarged section of a prism, with its lens, mounted in a metal fitting, the space not occupied by the glass being filled with blackened cork.

The rays of light (represented by three dotted lines) enter the base, *c b*, of the prism, and as they fall on it perpendicularly, they suffer no refraction, but pass directly, until they meet the inclined face, *c d*, whence they are reflected internally, and fall on the face, *q b*, from which they are again reflected internally, and emerge through the square surface, *d q*, at right angles to it.

The lens being cemented to the surface, *d q*, no light is lost by reflection at that surface, and the rays are brought to a focus at *e*, exactly in the same spot as would have been the case had the light passed, without the intervention of a prism, through a lens fixed at *f d*. There is, however, this important difference, that instead of the mean direction of the rays being perpendicular to the object, it is at a certain definite angle thereto, according to the construction of the prism.

Having made calculations to ascertain the relative angles and dimensions of the sides, which will produce the best possible effect for any given angle at which the bundle of rays is desired to fall on the object, I find that the following formulæ, which I have already supplied to Messrs. Smith and Beck, for the purpose of constructing the prism I have, will furnish all the particulars required.

The surface, *d q*, should be a square, the side of which we will call *s*. It is to this square surface that the lens is to be cemented. The other surfaces, *q d*, *b c*, and *c d*, are parallellograms, having their short side = *s*. The long side of *c d* we will call = *x*. Then let *a* = the angle at which the light is required to fall on the object.

The angle *q* = 45°, whatever may be the value of *a*.

Then the angle *b* = 135°— the angle *a*.

„ $c = 45° + \frac{\text{the angle } a.}{2}$

Then the angle $d = 90° +$ the angle $c$.

To find the value of $x$, cosine of angle $c : s ::$ radius $: x$.

To find the focus of the lens required, radius $: \frac{s}{2} ::$ cotangent of $\frac{\text{angle } a}{2}$ : focus + thickness of lens.

For the diameter of the lens, $\sqrt{2s^2}$ = diameter.

A square diaphragm, $c\ g$, equal in size to the square surface, $d\ q$, should be placed under the prism, as shown in the figure, that is, with one side coinciding with the angle, $c$, of the prism.

When in use the prism must be fixed under the stage of the microscope in a similar manner to that adopted with the achromatic condenser, it requiring all the motions of that piece of apparatus, and capability of being revolved on its axis in addition. In my own instrument the prism screws into the fittings of the condenser, in lieu of the lens, and the tube, carrying the rack and pinion, is made to revolve.

It of course requires centering to the object-glass in use, exactly in the same way as the achromatic condenser, as, if not properly adjusted, the spot of light goes out of the field of view on revolving the prism. This adjustment can, however, be very readily accomplished, and when once effected the light can be made to fall in any desired direction on the object, without in any way altering the disposition of the lamp or mirror, by simply rotating the prism.

These prisms can be readily applied to any of the instruments now in use, and the light produced, or rather affected, by them is much stronger than can be obtained from using the mirror to throw it obliquely. The degree of obliquity can also be made greater than by the mirror, owing to the thickness of the compound stage interfering with the latter, but not with the former. Of course the same precautions should be observed, when using these prisms, in noting observations to make the requisite allowances for the obliquity of the light, as would have been necessary had the obliquity been obtained in the usual manner.

By the assistance of one of Nachet's prisms, constructed according to the formulæ previously given, I have been able to see with a good quarter-inch objective the markings in *Navicula angulata*, and many minute lines, dots, and other minutiæ in numbers of the fossil *Infusoria* (so called), the existence of which I had previously no idea of. In fact, for this class of objects I can scarcely praise it too highly.

The few prisms of Nachet's own manufacture which I have had an opportunity of examining do not appear to be constructed exactly according to the formulæ I have given above; from what cause I am at a loss to conjecture, as I have no doubt of the correctness of these formulæ. I abstain from entering into the mathematical details, simply from a feeling that they would interest few, if any, of the members of the Microscopical Society.

Fig. 1.

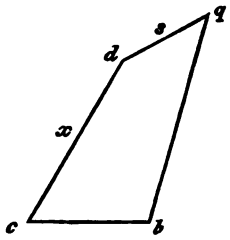



Fig. 2.

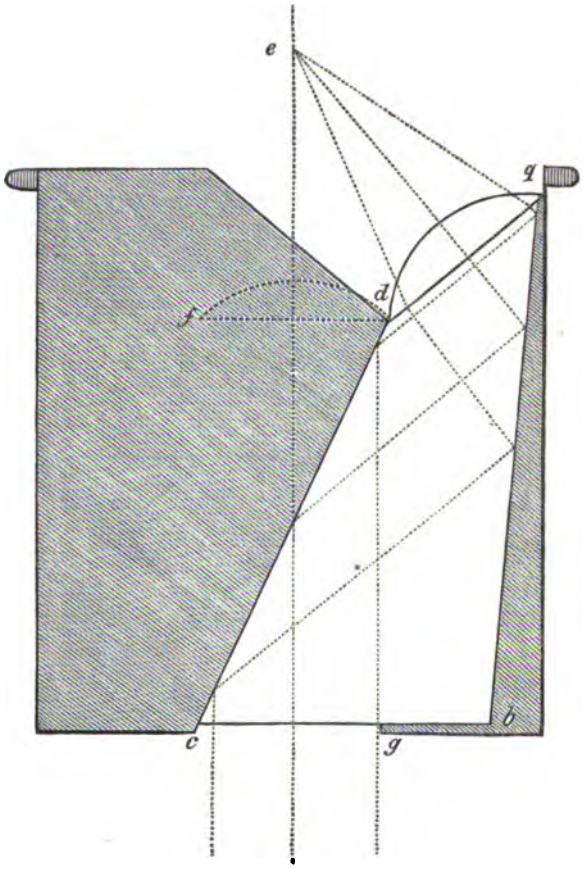


Fig. 3.

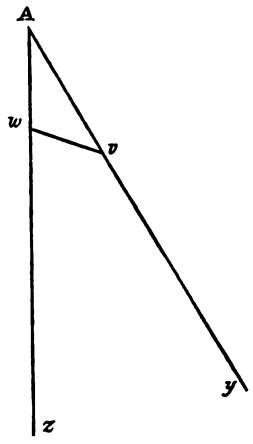



Fig. 4.

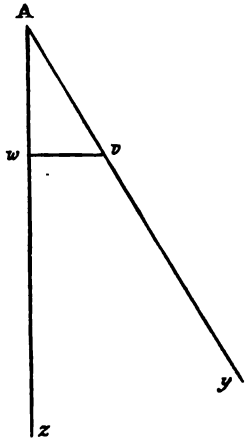



Fig. 5.

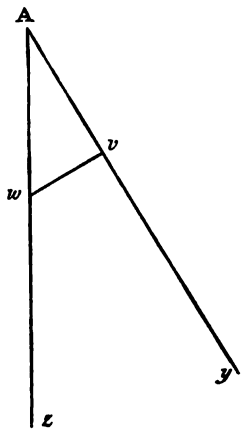



Fig. 6.

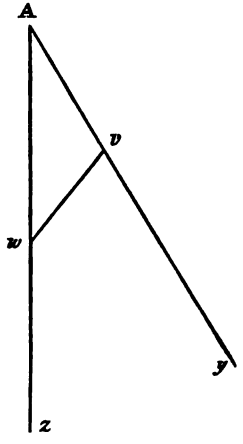
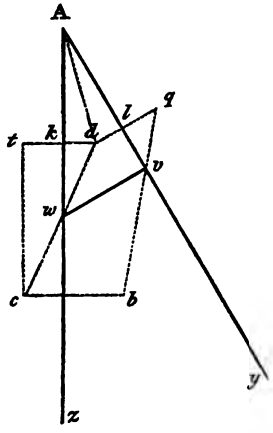



Fig. 7.



## XIV.—*Further Observations on the Construction of the Prisms of M. Nachet, for the Oblique Illumination of Transparent Objects on Stage of the Microscope.* By GEORGE SHADBOLT, Esq.

(Delivered verbally at the meeting of the Society in April, 1850).

AT the last meeting of this Society, which took place in March, I had the honor of reading a short paper, descriptive of M. Nachet's prisms, in which I put forth certain formulæ for their construction, but omitted the mathematical details of the mode in which these formulæ had been computed, from the conviction of the uninteresting nature of such a demonstration to the great bulk of the members. The correctness of them having, however, been called in question (in perfect good feeling), or rather the propriety of adopting any general formulæ, I am compelled to trouble you with the details alluded to, but will endeavour to do so with all possible perspicuity.

One of the objections made to my formulæ was, that even if they were applicable to the ordinary glass, they might not be to every kind of glass that might be made. My answer is, I only designed the observations to apply to crown-glass, and any of greater density, which, in fact, includes all in common use; and I readily admit that a glass might possibly be made which would not be applicable, in consequence of its density being too low, but I do not see how this affects the question. Another objection, relative to making the angle, *q*, figs. 1 and 2, always an angle of forty-five degrees, I shall answer in the course of my demonstration.

Let the line *z* A, figs. 3, 4, 5, 6, represent the course of a ray direct from the mirror to the object at A, on the stage of a microscope, and let *y* A represent the course of a ray falling obliquely at the angle desired; then it is a *sine quâ non*, that the course of the ray must be diverted from *z* A to *y* A, by two internal reflections in the prism. It is also necessary that two of the planes of the prism, *viz.*, *d q* and *c b*, figs. 1 and 2, be at right angles respectively to *y* A and *z* A, in order that the rays may enter and emerge perpendicularly, so as to obviate any refraction and consequent dispersion of the light. It therefore only remains to determine the relative inclination of the two lateral planes of the prism, with their respective dimensions, and the focus of the lens required. If the focus and aperture of the lens is first determined, the dimensions of the various planes will be dependent thereon.

It is a well-known law in optics, that when a ray of light is

incident on a polished surface, and the direction of the ray is from the more dense, towards the rarer medium (as from glass towards air for instance), when the obliquity of the incident ray reaches a certain point, the whole of the light is reflected, and none of it is transmitted. Now this is precisely the condition it is desirable to arrive at in the two internal reflections in the prisms under consideration. It is worthy of observation, that, provided the angle of the incident ray be sufficient to cause total reflection, there is no objection to its being somewhat more, though a less degree of obliquity would defeat the object.

The angle of obliquity, in order to produce the effect of total reflection, differs in the various kinds of glass (principally according to the density), and it also differs for the various coloured rays of the spectrum. If, however, an inclination of forty-five degrees be given, this is amply sufficient to cause total reflection for rays of every colour in any of the ordinary kinds of glass.

Referring to figs. 3, 4, 5 and 6, the ray *z* A, after its first reflection at *w*, must follow the course of one of the lines, *w v*, previously to its second reflection at *v*; that is to say, the course must be such as to make the angles *z w* A and *w v* A, either both acute angles, as in fig. 3, or the former a right angle and the latter acute, as in fig. 4, or the former obtuse and the latter a right angle, as in fig. 5, or, lastly, both obtuse angles, as in fig. 6. Now in the two former cases, figs. 3 and 4, it is manifest that, at one at least of the reflections, the inclination of the incident ray is insufficient to cause total reflection: it therefore only remains to decide between figs. 5 and 6, in both of which the inclination at both angles is sufficiently great.

There are two reasons which induce me to select fig. 5 in preference to fig. 6, while I know of none in favor of the latter. Firstly, fig. 5 does not require the prism to be so great in length as fig. 6 would; and secondly, by adopting fig. 5 a general set of formulæ for constructing prisms, for any obliquity, can be readily framed. Another objection that has been made to my adopting forty-five degrees for the angle *q*, figs. 1 and 2, I think it right to answer in this place, *viz.*, that if moisture were condensed on the sides of the prism, the obliquity would not be sufficient to prevent the ray being refracted out of it. My answer is, the remedy is simple; by wiping off the moisture (the prism can readily be mounted so as to allow of this being done), and, what is perhaps a more decisive reply, the same objection will apply to any angle that it is practicable to adopt, for unless the obliquity of the internal incident

ray exceeds sixty-two degrees this difficulty cannot be obviated; and it is obvious that in a prism of only thirty degrees such an obliquity of the internal incident ray as sixty-two degrees is impracticable.

For the foregoing reasons I conclude, then, that the construction as in fig. 5 is the best that can be adopted; consequently the side of the prism, *d c*, fig. 7, must be drawn so as to make the angles *d w v* and *c w z* equal to one another, and the side, *q b*, so that the angles *q v* A and *b v w* are also equal.

Having thus determined the inclinations of the various planes, let us now consider their respective dimensions; any two contiguous ones being settled, the others follow as a matter of necessity. There are two conditions to take into consideration, *viz.*, that the prism shall be capable of revolution without throwing the light out of the field of view; and that as much light (and no more) shall be capable of entering the prism as is capable of emerging from it. Draw *d t*, fig. 7, equal to *d q*, at right angles to *z* A, and let *z* A bisect *d t* at *k*, and *y* A bisect *d q* in *l*. Draw *t c* parallel to A *z*; then let *d q* be any convenient known size, which we will call *s*, and *d c* an unknown size, which we will call *x*. If *c d* be taken as the radius, *t d*, equal to *d q*, equal to *s*, is the sine of the angle *t c d*. But *t c d* is the complement of the angle *d c b* (called in fig. 2 the angle *c*); consequently the cosine of the angle *c* : *s* : radius *x*, the side required.

The focus of the lens required is evidently A *l*, less the thickness of the lens. Join A *d*; then, because *d l* equals *d k* (by construction), and the angles A *k d* and A *l d* are right angles, the angles *d* A *k* and *d* A *l* are also equal; consequently the angle *d* A *l* equals $\frac{\text{the angle } a.}{2}$ Now if *d l* be taken as the radius, A *l* will be the cotangent of the angle *d* A *l* or $\frac{\text{the angle } a}{2}$; and as *d l* equals $\frac{s}{2}$, the radius : $\frac{s}{3}$: : cotangent $\frac{\text{the angle } a}{2}$ : focus + thickness of the lens. A square diaphragm, whose side is equal to *s* (or *d q*), must be placed under the prism, so that one of its angles is coincident with the point *c*, fig. 2; the opposite angle of the same side will then be exactly perpendicularly under the point *d*, and thus prevent the entrance of any rays nearer to *b*, which would otherwise reach the surface, *d q*, without any reflection.

## XV.—*Note on Nachet's Prism.* By M. NACHET.

(Read April 17, 1850).

Paris, April 10, 1850.

Sir,

I HAVE received the note you sent me through your agent, and have to thank you for the trouble you have taken on the subject of the memoir read before the Microscopical Society. It is not at all surprising that the author (whose name I could not well make out) should have found that in our workmanship we were not theoretically correct. After all, we have not failed through ignorance.

We likewise have formulæ which we apply to the construction of my prisms. The whole question resolves itself into ascertaining the best form of prisms for causing the emergence of the utmost quantity of light through the terminal convex surface. In all these discussions a large concession must always be made to the practical part of the question, for the working of these prisms is sufficiently ticklish to prevent the production of any two whose side-lengths are exactly alike; the angles, however, *are* always exact, but vary in an ascertained manner, according to the different effects we may wish to obtain. I would, however, remark that there are divers combinations of angles, founded on the different inclinations that may be given to the luminous rays in the interior of the prism; for example, in the prism of forty-five degrees (which does not merit the few lines you have devoted in parentheses to acknowledgments) the angles of reflection are obtained in a different manner from the others. There are a great number of possible combinations, and I am very desirous of knowing how the author has been able to arrive at a general formula for all cases, and I would therefore beg you to send me his memoir, at least in abstract.

Yours, &c.,

NACHET.

Mr. Warren De la Rue.

## XVI.—*On the Illumination of Transparent Microscopic Objects on a New Principle.* By F. H. Wenham, Esq.

(Read April 17, 1850).

For the purpose of obtaining the perfect definition of microscopic objects under high powers, it is important that the light should be achromatic, and that the illuminator or condenser should transmit a large angular pencil of rays; also the markings on test-objects are in most instances more readily discovered by throwing the light on them obliquely.

In the prism of Nachet, which is especially intended for oblique illumination, the attempts made to obtain a large aperture, and to correct the chromatic aberration, have not been successful; consequently there is a want of light, and objects illuminated by it show some colour.

In order to remedy the defects of chromatism and want of aperture, the following arrangement was completed and tried (see plate XIV. fig. 1). A is an ordinary achromatic lens, of an inch focus. B is a square prism of dense flint, with a polished surface, C, making an angle of 67½ degrees to the base. At D is a double convex lens of crown glass, of a quarter of an inch radius, cemented into a corresponding cavity of the same curvature, worked in the base of the prism, by which means it is made achromatic.

At the apex of the prism is another double convex lens of crown glass, E, with the contact surface of ⅛th of an inch radius, cemented in the same way as at D. The total curves of the glasses are arranged so as finally to produce achromatic light.

The rays of light, after passing through the glasses A and D, are reflected by the polished surface, and then farther condensed by the lens E, placed at right angles to the axis of the emergent rays. This arrangement has a similar effect to three achromatics, shown by the dotted lines (which represent the concaves by that portion of the prism they cut off), in combination with a reflecting surface.

By means of this appliance a pencil of light was thrown obliquely at an angle of forty-five degrees across the object, an aperture of sixty degrees was obtained, and by the combination the markings on the *Navicula angulata* have been shown with a quarter-inch object-

glass, though not satisfactorily, for on attentively observing the effects produced, it is apparent that the principle of transmitting oblique light through a transparent object, in one direction only, is faulty, as it appears on some objects (the *Podura* for instance) to elongate the markings, if either projections or depressions, and gives to dots or concavities the semblance of lines, producing a kind of overlapping shadow (at some distance above the object), upon which the markings are seen; the light also being in some degree decomposed by the margin of the object, the outline is rendered indistinct; which circumstances are sufficient to show that there is a defect in the principle of illumination from *one side only*.

This appearance of a shadow suspended over the object, in a position opposite to the direction of the light, would lead us to conclude that, in order to balance this defect, the oblique rays should be counteracted by a pencil of light, of similar form and intensity, thrown on the object, at the same angle, from an opposite direction. This it is proposed to effect, as shown by fig. 2, by means of two of Nachet's prisms, placed in juxtaposition, and made to revolve under the stage of the microscope, for the purpose of placing the two pencils of light in various directions across the object.

The prisms should either have achromatic glasses, cemented on at AA, or be made of flint, with double convex lenses of crown glass, cemented in as before mentioned. Between the two prisms at B there should either be a dark well or a black ground, and at the base there should be a square diaphragm, CC. Although this arrangement has not yet been tried, there is some reason to suppose it would answer well.

The cause of the markings on test-objects being seen by oblique illumination, which cannot be shown by the ordinary method, appears to be that in the former case no greater amount of light is allowed to pass through the object into the object-glass than is sufficient to render the structure distinctly visible, consequently the object is not drowned by an intense glare of light, which is sometimes occasioned by ordinary direct illumination. From this it would appear that no rays from the source of light should enter the object-glass by passing through or around the object, which must be illuminated by very intense light, thrown on in all or opposite directions, at an angle exceeding the aperture of the object-glass, so that the light which enters the microscope should be that which radiates only from the object, as if it were self-luminous.

Those who have experimented on the subject may have observed that there is something in the nature of oblique light, reflected from a metallic surface, particularly favourable for the purpose of bringing out minute markings, which may in some measure be attributed to the circumstance of light so reflected being purely achromatic; and in order to avail myself of this property, I have designed a method by which the condensation of lateral light may be effected by means of a metallic reflector.

The apparatus is drawn in fig. 3, the size of the original. AA is a parabolic reflector, of a tenth of an inch focus, with a polished silver surface, having the apex so far cut away as to bring the focal point at such a distance above the top of the apparatus (which is closed with a screw cap when not in use) as may allow the rays to pass through the thickest glass commonly used for mounting objects upon, before coming to a focus. At the base of the parabola is placed a disk of thin glass, BB, in the centre of which is cemented a dark well, with a flange equal in diameter to the aperture at the top of the reflector, for the purpose of preventing the direct rays from the source of light from passing through the apparatus. The dark well is rather less than the diameter of the flange, and must be raised as high as may be found necessary to prevent the light from the reflector from entering the object-glass.

The reflector is moved to or from the object by means of the rack and pinion, C, and has similar adjustments for centering, and is fixed under the stage of the microscope in the same way as the ordinary achromatic condenser; in addition, there is a revolving diaphragm, D, made to slide on the bottom tube of the apparatus; it has two apertures, EE, placed diametrically, for the purpose of obtaining two pencils of oblique light in opposite directions.

The effects of the chromatic and spherical aberrations, in the shape of fog and colour, about the objects, caused by the glass slides upon which they are mounted, were sufficiently conspicuous, when illuminated by the reflector just described, as to require a means of compensation, for as the parabola has the property of throwing parallel rays uncoloured to a point, when used alone it is most suitable for an object without glass underneath it.

Fig. 4 represents the aberrations of a large angular pencil of rays, caused by a plate of glass. AA are rays reflected from the surface of the parabola, proceeding in the direction of the focus, B, as shown by the dotted lines. CC is an interposed plate of glass, which

refracts the marginal or more oblique rays in a greater ratio than the central ones.

The rays of light, after leaving the second surface of the glass, proceed onwards, parallel to their original direction, and intersect the axis at various distances, producing a longitudinal aberration, nearly equal to the thickness of the glass, the point of the marginal or outstanding rays being the most distant.

The effect of a flat, parallel plate of glass upon a pencil of rays is that of over correction, or, in other words, the aberrations, both chromatic and spherical, are contrary to those produced by a convex lens, in which the marginal rays are brought to a focus nearest to the lens, while the central ones are thrown to a more distant point.

It appears from this that if a lens of proper focus and curvature be placed at the apex of the reflector, it will neutralize both the chromatic and spherical errors caused by a certain thickness of glass under the object. This result has been obtained, as shown by fig. 5 (drawn four times the full size). AA is a meniscus, of 1·4 in. focus; the radii of the surfaces are as 4· to 3·125. This is shown in the diagram, in such a position that the centre of the convex surface of the meniscus is in the focus, B, of the parabola, therefore the rays of reflected light, CC, proceeding towards the point, B, enter the under convex surface of the meniscus radially, without suffering any refraction; and after meeting the concave surface, and emerging therefrom, the outstanding rays intersect the axis at D, while the inner ones are thrown more distantly, as at E, producing a longitudinal aberration from D to E, as shown by the dotted lines, thus giving a sufficient amount of under correction for glass a twentieth of an inch thick, for it is shown that by interposing a plate of glass, FF, of that thickness, the focus of the marginal rays is brought up to that of the inner ones, so that the whole pencil of rays comes to a point through the glass.

Fig. 6 is given for the purpose of showing that there is a means of adjustment for all thicknesses of glass under a twentieth of an inch. B is the focus of the parabola. The dotted outline represents the position of the meniscus, as shown in fig. 5. AA is the meniscus lowered from its former position. The centre of curvature of the convex surface of the meniscus now being under the focus of the parabola, the rays enter that surface at an angle, or otherwise than radially, and after being refracted by both surfaces of the meniscus are brought to a focus. It is then suitable for an object without any glass underneath it.

By the addition of the meniscus we obtain greater purity and intensity of illumination, and as the silver reflector is now closed with glass, it is hermetically sealed and permanently protected from dust and damp, and will therefore retain its polish.

The advantages expected by these arrangements have been realized, the apparatus answering the purpose of an illuminator for all the object-glasses, the objects being seen on a black ground.

The light most suitable for this method of illumination is lamp or candle-light, the rays of which must in all cases be rendered parallel, by means of a large plano-convex lens or condenser; the light may then be used direct or reflected from the plane mirror. The object having been adjusted, the illuminator is moved to or fro till the best effect is produced.

For the purpose of viewing some objects, such as the *Naviculæ*, the circular diaphragm should be slid on the extremity of the apparatus, and revolved till the two pencils of light are thrown most suitably across the object.

All objects, either transparent or opaque (excepting white), absorb some of the rays of light; they are rendered visible by that portion which they radiate; and a predominance of those rays, either primary or compound, of which ordinary white light is composed, is the cause of their various colours, the intensity of which depends on the quantity radiated; therefore any object tolerably capable of radiating light will be well shown by this method of illumination, and in all their natural colours (if the light thrown on them is achromatic). For these reasons it is probable that it is the radiant rays of light, coming only from some objects, that we ought to see, and that all the light surrounding, and also that coming directly through, the object, is in some cases not only useless, but detrimental, for reasons I shall now explain.

In viewing objects by light transmitted directly through them, we have two sets of rays entering the eye, *viz.*, those emanating from the source of light and those radiating from the object, the imperfections produced by the former passing through and around the object, mingling with the latter, and preventing them from producing their proper effect. The defects I allude to in direct illumination are caused by the interference of light, the effects of which may be illustrated by the following experiment. Make a hole in the window-shutter of a darkened room, of about a thirtieth of an inch in diameter, upon which fasten a lens, of an inch focus, centrally. When either a transparent or opaque object is held in the beam of

light passing through the aperture and lens, it will be seen that the outline of the shadow is surrounded by a coloured fringe. This is the visible effect of the interference of light. The same may be shown without the lens, but not so plainly.

The intended limits of this paper will not allow me to go into the details of these phenomena, therefore I shall only mention the effects of interference observed under the microscope. It will be seen that there is a faint band or fringe surrounding minute objects seen under high powers, by ordinary illumination, which prevents the outline from being distinctly marked: even under our very best glasses the effect of this interference is seen around the margin of a minute filament or hair, but most especially by the *Monas termo*, the smallest of the *Infusoria*, which appears as a little, moving, nebulous spot of light, which when shown by its own radiant light, produced on this new principle, is perfectly developed, both for outline and colour. The effect of this interference on some transparent *Infusoria* and other objects, is to blend together the complex internal organization, which they ought to display when seen only with their own light, that, from the source of illumination, being prevented from entering the object-glass.

As the method of illuminating microscopic objects by means of a very large angular pencil of light, having the central rays obscured, is but just introduced and therefore a novelty, I shall mention in corroboration a few instances where transparent objects are shown, under similar circumstances, with perfect or improved definition.

If a small black wafer be fixed to a window, against the brightest part of the sky, and a large transparent object, such as a feather or the wing of a dragon-fly, be held before it, and examined with a hand-magnifier, of about an inch focus, it will then be entirely illuminated by lateral light, and it will be seen that the object is more beautifully developed than when shown against a bright cloud, the comparison being immediate.

Also it may be observed that the structure of a muslin curtain immediately before the bar of a window is more readily ascertained than when directly opposed to bright skylight.

Those who are in the habit of collecting *Infusoria* will be assisted in distinguishing the various species, if a slip of black cloth be cemented to the further side of the phial, which should be held directly against the sky, and the contents examined with a Coddington lens or hand-magnifier.

Other examples, under our every-day observation, might be cited

of transparent objects being better seen where the direct light is entirely or partially intercepted, for I should observe that some objects, especially those of a dark colour, are better shown on a ground either coloured or slightly illuminated. This circumstance is provided for in the reflector by turning out the bottom of the dark well, so that patches of tissue-paper, more or less diaphanous or variously coloured, may be used for the back-ground of the object. I shall now explain why, on test-objects and the internal mechanism of *Infusoria*, markings can be seen by this method which are invisible by the ordinary way of illumination.

There is but little doubt that the markings on most of the test-objects are either depressions or projections. By the usual direct light all parts of the surface of an object, whether raised or depressed, are illuminated with nearly equal intensity, and the strong direct light partially destroys delicate colours; consequently there is a want of contrast.

The effect of an angular pencil of rays of a hundred and seventy-five degrees, with the central ones stopped, is, that there is a greater relative amount of light thrown on these prominences, as they intercept the largest portion of the circular marginal or most oblique rays near the apex of the reflector (which are thence the most effective), leaving the base of the prominence in comparative shadow; consequently the very markings we wish to see are the most strongly illuminated.

The different organs in the interior of an animalcule may be much of the same transparency and colour, and yet possess a different refraction, according to their density; therefore the illumination should, if possible, be so arranged as to take advantage of this circumstance. Now direct light will pass through these transparent membranes in straight lines, without being affected by their various refractive powers. The effect of lateral or oblique light on such tissues is, that the rays are more refracted according to their inclination, and proportionate to the various densities of the medium; the most refractive structure transmitting the greatest quantity of light, and is in consequence more illuminated, and this reason is somewhat confirmed by the circumstance of this circular or lateral illumination showing the structure of some objects which, from slight variation in density, are invisible except by the polariscope.

I have thus endeavoured to place my ideas of microscopic illumination before the Society in an intelligible point of view, though perhaps not very systematically, as to treat the subject fully would

require a long and patient experimental inquiry, for which I have not yet had leisure, but I give my theory in its crude state, with the view of inducing others to follow the same path, and try its effect by different means, for I must observe that I adopted a truncated reflector, placed under the object, as the readiest means of carrying out the theory, and obtaining the purest light and utmost limits of aperture; and if this effect is obtained, either by reflection or refraction, and all the niceties of the principle attended to, it will be found a valuable adjunct to microscopic discovery, for from appearances I have observed with it, it is my belief that, on account of the defects of direct transmitted light which I have attempted to explain, many transparent objects, from the earliest age of the microscope till now, have been seen under false appearances. This may appear a presumptuous assertion, but I confidently trust to time to prove its accuracy.

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## EXPLANATION OF PLATE XIV.

Fig. 1. An arrangement for obtaining a large angular pencil of achromatic light, reflected obliquely across the object in one direction.

Fig. 2. Two of Nachet's prisms, placed so as to throw two equal pencils of oblique light across the object from opposite directions, in order to balance the defects arising from such illumination from one side only.

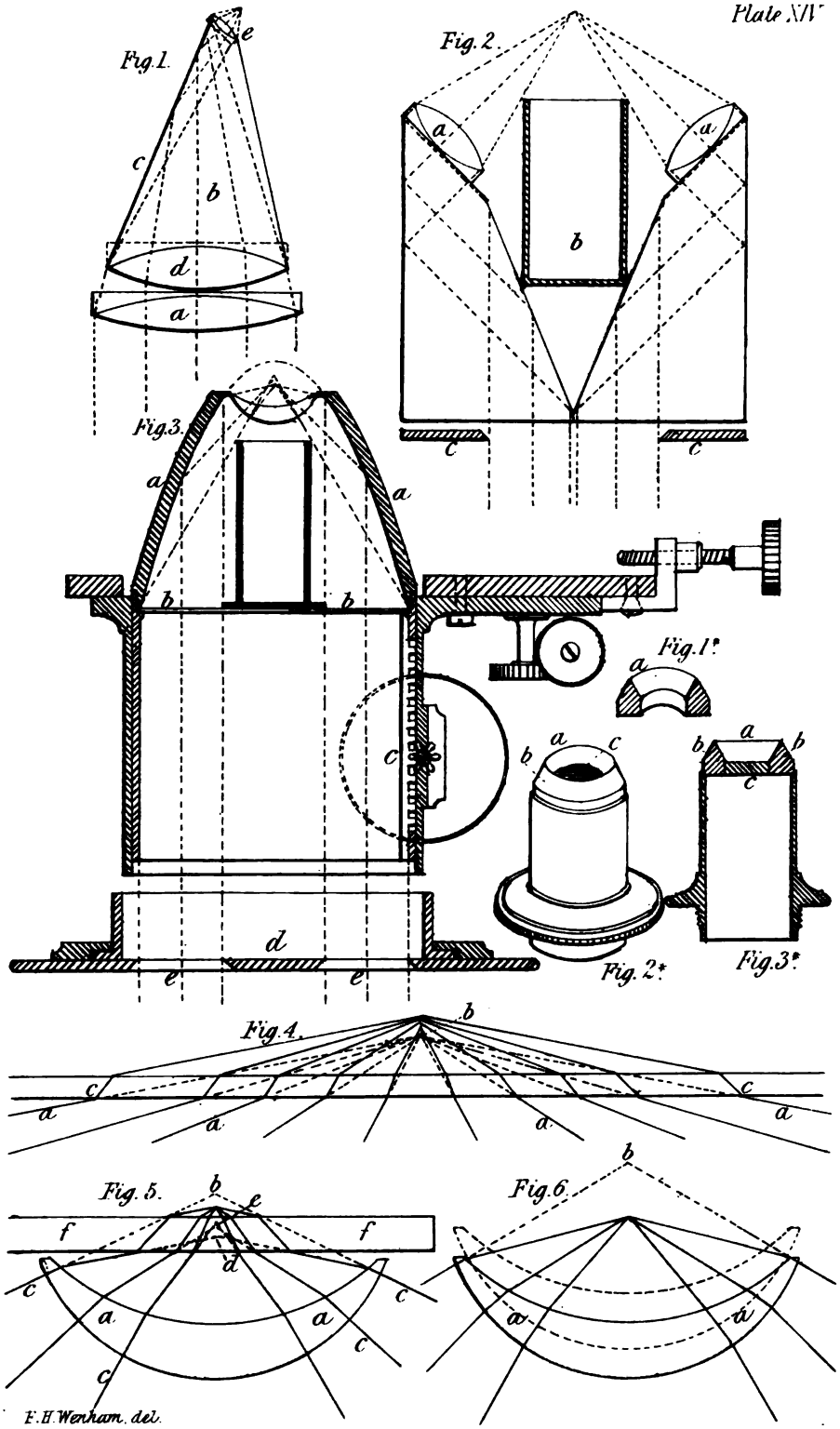
Fig. 3. A truncated parabolic reflector for condensing lateral light upon transparent objects; all rays from the source of light are prevented from entering the object-glass, and a black field is obtained by means of an adjusting dark well, placed in the centre of the reflector, and supported by a glass plate, BB.

Fig. 4. Represents the aberrations produced on the large angular pencil of rays from the reflector by passing through the plate of glass upon which objects are mounted.

Fig. 5. Shows the method of correcting the aberrations. The rays from the reflector are refracted by the concave surface of the meniscus, AA., placed at the apex, and after passing through the glass slide, FF., are brought to a point.

Fig. 6, AA. The meniscus lowered from the position shown in fig. 5; the rays being refracted by both surfaces, are brought to a focus.

Plate XIV



## XVII.—*On the occurrence of Non-Gymnospermous Exogenous Wood in the Lias, near Bristol.* By Henry Clifton Sorby, Esq., F.G.S.

(Read May 15, 1850).

It has usually been thought, that in rocks of the age of the lias, non-gymnospermous exogenous wood does not occur. When I was at Bristol a few years ago, I purchased of a fossil-dealer, at Clifton, a piece of fossil wood, which he informed me was from the lias at Keynsham: not having at that time paid any attention to the structure of woods, I did not specially remark its non-gymnospermous structure, and therefore did not make such particular inquiries as to its locality as would have been desirable; and hence the fact of its occurrence in the lias rests solely on the information which I obtained from him. Its appearance and chemical composition, however, perfectly agree with those of the coniferous wood so common in the lias, and I therefore think that there is good reason to believe it to have come from that bed. The piece which I possess is only a portion of the stem, and shows very distinctly the surface directly below the bark, but does not extend to the pith; and, judging from the curvature, the diameter must have been somewhere near one foot. The annual growths are moderately distinct, and about $\frac{1}{5}$th of an inch in thickness.

The drawing will convey a much better idea of its structure than can be given by description. Pl. XVI. fig. 1, which, as well as figs. 2 and 3, is magnified 100 diameters, is a transverse section, and shows the medullary rays and variously-arranged ducts. Fig. 2 is a longitudinal section, showing the structure of the interior of the ducts, and a portion of a medullary ray. Fig. 3 is a tangential section, and also shows two ducts, and the medullary rays cut across; from which the great proportionate size of the latter will be seen. The sides of the ducts are marked, as shown in fig. 4, which is magnified 200 diameters; but it is only in some few places that this structure is well preserved, being in many cases much confused, no doubt by decomposition having partially occurred before it was perfectly mineralized.

"When not highly magnified, and where the structure is not well preserved, some of the larger ducts appear as if they had a spiral fibre wound round them, as shown in fig. 3; but when more highly magnified in a part where the structure is well preserved," it is found to result from such markings as are shown by the larger duct in fig. 4. The very elongated ovals shown in the lower part of it are on the outside of the membrane of which the duct is composed, and the circular ones are on the inside. This is readily shown by the focal adjustment, and by the manner in which they occur when the duct is cut through in making the section, as is common in recent exogenous wood, the ducts often contain irregular membranous divisions, as will be seen from all the drawings.

There can thus be no question of this wood being a true non-gymnospermous exogen; and its occurrence in the lias is of course a fact of considerable interest, as proving that trees of that character existed at a much earlier period than has hitherto been generally supposed.

I have made many sections of woods belonging to various natural orders of exogens, with a view to learn whether the natural affinity of the fossil could be determined from its structure, but have been unable to determine any rules from which this could be ascertained; though a much more extended examination might perhaps solve the question.

## XVIII.—*On the Anatomy of Notommata aurita, an Animal of the Class Rotifera.* By P. H. Gosse, Esq.

(Read May 15, 1850).

The animal which I propose to describe appears to have been seen by only two observers, Müller and Ehrenberg. The latter quotes indeed, with a mark of doubt, our own countryman Baker, but I see little reason to identify his description or figure with this species. Müller, in 1786, described and figured its external form, and named it *Vorticella aurita;* and Prof. Ehrenberg, first in the 'Berlin Transactions,' in 1830, and recently in his noble volumes on the *Infusoria*, has added to our knowledge some of the more conspicuous organs, and has included it in his genus *Notommata.*

The eared *Notommata* is an inhabitant of our fresh waters, especially those which are still and occupied with aquatic vegetation. I first obtained it from a reservoir in my own garden, about the half-decayed leaves of the common duckweed (*Lemna minor*). More numerously it occurred in water from a pond in the grounds of Samuel Berger, Esq., of Hackney, in which the yellow water-lily grows. But still more abundant I found it in a jar of water obtained last autumn from a pond near Walthamstow, which had stood in my study-window through the winter. In February, I found the sides of the phial swarming with this *Notommata*, and with a species of *Salpina.*

This fine species is about $\frac{1}{70}$th of an inch in length, when extended (as at Pl. XII. fig. A.); but its contractions and elongations render it ever varying. Its form viewed dorsally is somewhat cylindrical, but it frequently becomes pyriform, by the repletion of the abdominal viscera. Viewed laterally (as at B.), the back is arched, gibbous posteriorly, with the head somewhat obliquely truncate, the belly nearly straight. The posterior extremity is produced into a retractile foot, terminating in two pointed toes: this, both in function and structure, is certainly analogous to a limb, and must not be mistaken for

a tail, inasmuch as its position is anterior to the cloacal orifice. A minute projection behind the cloaca forms a sort of tail. When not swimming or rotating, the head assumes a rounded outline (Pl. XIII. fig. C), displaying through the transparent integument an oval mark on each side, within which a tremulous motion is perceived; but at the pleasure of the animal a semi-globular lobe is suddenly projected from each of these spots by evolution of the integument. These projections have suggested the trivial name of *aurita*. Each lobe is crowned with a wheel of cilia, the rapid rotation of whose waves forms the principal source of swift progression in swimming. The protrusions of these lobes are evidently eversions of the skin, ordinarily concealed in two lateral cavities. They may be protruded by pressure, and are then seen to be covered with long but firm and close-set cilia, which are bent backward and moved more languidly as death approaches. The whole front is also fringed with short, vibratile cilia, which extend all along the face, as far as the constriction of the neck. The whole body is clear and nearly colourless, but its transparency is much hindered by the net-work of dim lines and corrugations, that are everywhere seen, particularly all about the head. It is only by subjecting the animals to various degrees of pressure by means of a compressorium, or of glass plates, and by the examination of a great number of specimens, that a satisfactory demonstration of the internal structure can be obtained.

The digestive apparatus shall have our first attention. Near the head is seen a large oval or cylindrical transparent sac, placed towards the ventral rather than the dorsal side, but capable of much motion and change of place; sometimes it is suddenly drawn down nearly to the foot, while at others its front part is brought into contact with the matters on which the animal feeds. This viscus I shall call the *gizzard*, as its office is the trituration of the food to prepare it for digestion.

The implements of mastication within the gizzard are elaborate and complex. They consist of two bent jaws, which work upon a central table, and have been likened to a pair of hammers working on an anvil; I shall therefore name the working arms the *mallei*, and the central table the *incus*. This apparatus, with many modifications of detail, characterizes the dental system of a large number of the *Rotifera*.

When viewed *in situ*, the *incus* is seen to consist of a long slender foot, apparently dilated at the bottom, and carrying on its upper end a complex array of tabular pieces, which, from the obscurity of this part, are very difficult to be made out. They appear, however, to

consist of two convex shields, with two or perhaps four descending points; one is placed above the other, and the convexity of both is upward. The knobbed foot is evidently jointed to the under surface of the lower shield, for the whole upper part is capable of considerable motion from side to side, as on a pivot, while the foot is steady. The foot reaches to the very bottom of the gizzard, and the end which in one aspect appears dilated, in another seems to have a curved spoon-like extremity.

The *mallei*, viewed *in situ*, appear each to consist of a rod, hanging freely down in the gizzard, nearly parallel to the *incus*, but slightly bowed outward, and of an arm or head, set on its upper end, nearly at right angles. The end of this arm appears cut into teeth, which meet those of the opposite one upon the surface of the upper shield of the *incus*. A figure of the apparatus thus viewed is carefully drawn at G; the dotted lines representing the position into which the *mallei* are alternately thrown in the process of mastication. The specimen from which this figure was taken afforded me an unusually good observation. On putting carmine into the water, and examining the animal carefully with a power of 300 diameters, the jaws worked slightly, the points opening a little way, and then closing; the rods of the *mallei* were drawn towards the bottom for opening, and upwards (as in the dotted lines) for closing. A little mass of pigment was soon accumulated beneath the tips of the jaws, which spread itself over a rounded surface (fig. G), but did not pass farther, nor did an atom at this time go into the stomach.

On applying pressure by means of Mr. Ross's compressorium, the structure of this apparatus becomes more clearly resolved. From many examinations, I have found that the rod of the *malleus* (fig. E) is a long loop of bone (or a substance analagous to it), one side of which only (the interior) is attached to the head-piece, which, nevertheless, has a descending process that nearly meets the outer side of the loop, and is, I think, connected with it by the soft part. The head-piece has also another process, descending obliquely behind the loop. I have distinctly seen floating bands (muscular?) attached to the bottom of the gizzard by one end, and by the other to various parts of the bony frame-work. One pair of these proceed up to the oblique hind processes (one to each), to the extremities of which they seem attached: another pair go from the foot of the table to the curved points that project on each side; their attachments to these points I saw very clearly: another pair less clearly appeared to pass up to the higher parts of the table between it and the loops. All

these bands were broad at the lower ends, and tapered to the points of attachment. They were very loose, and were moving with an irregular waving or floating motion, as if surrounded by fluid. The pressure applied was moderate.

On another occasion, by carefully applying strong pressure, I was able to see the structure of the jaws better than before; the result is delineated at F. A hand of five diverging fingers (1 and 3) united, I think, by membrane, is jointed to the frame-work of the *malleus* (2), and works on the rounded surface of the *incus* (5). The position of this hand, *in situ*, is horizontal, and hence only its edge meets the eye of the observer (as in G), until it is displaced by pressure. That the frame-work (2) is all in one piece, and not jointed, I proved by pressing on the glass-plate with the point of a pen; for thus by increasing or lightening the pressure, after the compressorium had done its utmost, I was able to jerk the parts to and fro. I found that the frame-work (2) moved bodily, without the slightest change in the relative position of its parts, but that the hand (1) did not move with it, but merely remained in contact with the point of 2. The foot (4) of the *incus* is flat, and bent at the extremity. Parts of the structure were indistinct; and the details of the top of the *incus* are still obscure.

Now and then a curious appearance is presented, as if a membrane were suddenly withdrawn from around the *incus*, leaving a circular opening, which enlarges, or narrows, or moves up and down. It appears oval, viewed in perspective (fig. G), but I conjecture that it is not *around* the *incus*, but between it and the observer's eye, and that it is the orifice of the duct leading from the gizzard to the stomach, opening or closing.

In a lateral view this duct is perceived (fig. B) to be long and slender, and to be capable of still further elongation, and also of contraction. It opens into the alimentary canal, the head of which is abruptly swelling, and carries on each side of it a globose clear gland; these glands, doubtless, secrete and pour into the digestive canal a fluid accessory to nutrition, but whether pancreatic or biliary, I cannot say. This viscus itself is wide, subcylindrical, but tapering towards the anal extremity, not divided by any constriction, but fulfilling the offices of stomach and intestine. The walls are very thick, and probably cellular, leaving only a central tube for the admission of the food. This tube is readily seen when charged with food (as in A), and may be rendered beautifully distinct by the admixture of carmine with the water (fig. B). The cloaca is just between the

caudal point and the base of the foot. The whole internal surface of the canal is probably lined with innumerable vibratory cilia, for, though I have not observed them in this species, I have noticed them commonly in the *Rotifera*.

All the members of this class are considered to be hermaphrodite, and the species before us is (exclusively, as far as I am aware) oviparous. The female organism is always conspicuous, consisting of an enormous ovary, occupying the ventral region, commonly on one side. Sometimes (as in A) it is a long, clear viscus, containing many transparent globules, the rudimentary ova; and sometimes it is granulated (as in B). Often a great developed egg may be seen (as in A) occupying a large portion of the abdominal cavity; and sometimes a second, also large, but less advanced to maturity. The eggs that I have seen laid have been but few; they measured about $\frac{1}{110}$th of an inch in length, and were covered entirely with short, flexible spines. This was, however, in winter; at another season, they would probably be smooth. An animal which I isolated on the 19th of February, with a large, nearly matured egg, deposited it on the 21st. Voluntary motion of the fœtus was perceptible in a day or two afterwards, and from that time till the 1st of March, I saw every day, through the transparent shell, the working of the body, the vibration of the cilia, and an opaque, cloudy mass near the middle, probably the ganglion. On that day, I lost it, eight days after laying, and about a week after the first appearance of fœtal life. The eggs of the *Rotifera* are ordinarily hatched in about twenty-four hours.

Among the male organs may be reckoned, according to Prof. Ehrenberg, that singular viscus, found in nearly all the *Rotifera*, and in many of the *Polygastrica*, the contractile bladder. It occupies the lower part of the abdomen, and when distended (as in B) takes up a large space, displacing the surrounding viscera. It slowly fills, and suddenly contracts into a wrinkled point, and these distensions and discharges go on alternately; but not at all times, for in many specimens the organ cannot be seen at all. When distended, it appears so clear that one might imagine a hole to have been cut through the whole substance of the animal; but on careful examination, numerous irregular vessels or muscular bands (?) are seen to meander and ramify over its walls.

A string of tortuous vessels, consisting of three at least, loosely twisted together, run down the whole length of the body, on each side (see H, 1). They commence near the head, and evidently terminate in the contractile bladder (H, 2) at its posterior extremity.

Prof. Ehrenberg considers these to be seminal glands; that some fluid is poured by these into the bladder, and discharged when it is full, I think hardly any one can doubt who watches the operation; but when we consider that the successive fillings and discharges rarely occupy more than a few minutes, and in many species are performed many times in a minute, though with a very uniform periodicity,—it is hard to think that so great a quantity of fluid can be so quickly secreted. Can it be that the bladder is an organ connected with respiration? The tortuous vessels carry attached to them, at various points of their extent, little pear-shaped, tremulous organs. They do not always tremble, nor always together, but are very irregular and intermittent; hence it is difficult to say how many there are, but I have distinctly seen four on each side (H, 3, 3), two near the penultimate transverse muscle, and two near the neck. When trembling moderately, they are seen to be little oval bags attached to the tortuous vessels by a neck, and free at the other end; a spiral vessel closed at the extremity runs through most of the length, which maintains a waving motion. When the trembling is rapid, the little bags are dilated at the end (H, 4), and appear as if covered with transverse parallel waves or bands, which run into each other, and disappear successively. In both cases the progress of the waves is from the free extremity towards the neck or base. At the lateral insertions of the antepenultimate transverse muscle a membranous (?) band is fastened to the skin (H, 5), which is attached to the side of the tortuous vessel with a dilated extremity, probably acting as a ligament.

I have no doubt, with Prof. Ehrenberg, that the little trembling organs are branchiæ; but why should these be attached to the seminal glands? I do not believe, as he does, that water is admitted freely into the visceral cavity; but may it not permeate the tortuous vessels, be decomposed by the internal (not by the external) surface of the trembling bodies, and then, having performed its office, be poured, effete and waste, into the contractile vesicle, to be discharged through the cloaca?

Water appears to be constantly percolating into the alimentary canal, even when the jaws are perfectly still; for there is a succession of little transverse waves continually crossing the neck of this viscus, just below where the duct from the gizzard opens into it.

Parallel with the gizzard, but nearer the dorsal surface, is a large sub-globose mass of dense matter, white by reflected light, black (because opaque) by transmitted. It occupies the bottom of a deep

cylindrical sac, common to most of the *Rotifera*, though I know of no other example of this dense body occupying it. The sac is capable of much motion, quite independent of that of the gizzard, sometimes being retracted, sometimes drawn towards the ventral surface, or to either side. There is a tube running through the centre of this occipital sac, which widens at its lower end to embrace the white mass. The latter is arranged in numerous lobes, sometimes very distinct (as in A), at others more consolidated (as in B), and the whole mass occasionally contracts irregularly, when the matter, in the form of dense granules, is partially forced up into the tube, again falling when the mass expands. That this is a great ganglion or cerebral mass of nervous matter, is probable, from its being the seat of the great coloured eye; although we certainly do not expect to find such a concentration of neurine in an animal of this low grade: at all events, I shall take the liberty of so designating it. At times the eye is scarcely perceptible, then suddenly it becomes visible like a flush of crimson, rich in hue, but rather pale, ill-defined (B), lying on the summit of the ganglion. In other specimens its form is very distinct, like a convex lens of ruby, just beneath the widened base of the tube (A). It does not change its form or position, even when the cerebral granules are forced up the tube, to which it seems to present no obstacle. Under strong pressure the pigment escapes, and resolves itself into three or four minute red globules, not quite alike in size.

The ganglionic tube, after pressing through the centre of the occipital sac, appeared in one specimen to make an abrupt bend, turning down towards the interior of the body. The walls were not visible, it is true, but the motion of the dense granules, projected or retracted in it, exactly like the mercury in a thermometer if you present it to the fire or remove it, distinctly showed the form as they moved backward or forward. Yet, as I afterwards found, that the direction of the curve is towards the front of the head (as in D), where it can no longer be traced, this apparent retrogression was probably only an optical illusion, caused by the front being bent much forward, while the view was taken from behind.

There may often be seen (figs. H and I) running round the front of the head, parallel with the skin, a tube (1) which sends off irregular branches inwardly that open into another tube. It is not always visible, and I have not been able to trace the termination on either side. It does not appear to have parietes, but to be hollowed in the

flesh, or to be produced by the separation of the irregularly rounded masses of which the head is composed.

I come now to speak of the system of muscles, which I have been able to define satisfactorily, to an extent that had not before been done, though I am sure many more remain to be demonstrated. The precise, vigorous, and most numerous motions of which the more highly organized *Rotifera* are capable, presuppose the existence of a complex array of muscles; and the specimen which I am able to show, may prove to us how elaborately these are supplied; and, combined with the other organs, should excite our adoring admiration of the infinite resources of Him, whose "eternal power and Godhead" are manifested not less in this minute and even invisible organism, than in the structure of an elephant or a whale.

Across the body, nearly at equal distances, are seen to run six (or seven ?) transverse muscles, inserted by dilated ends into the interior separable skin on each side (I, 2). They are either attached through their whole length to the inner surface of the integument, or else they are arranged in pairs, inserted in the mesial line of the dorsum, and running to each side; for in a lateral view their ends are seen still to touch the dorsal outline (D); but I do not think they extend quite across the belly. Prof. Ehrenberg thinks them (in *Hydatina*, &c.) to be vessels, but they closely resemble the longitudinal muscles. If they are muscular bands, their use is doubtless to contract the diameter of the body, which is often done powerfully, and most strongly at the points where these are placed.

A bent vessel (?) (*i*, 3), passes down each side. The transverse muscles *appear* to pass through the substance of this, which divides and again unites to embrace them; but of this I would speak doubtfully. At the hindmost transverse band, it passes round, and being bent up again, proceeds diagonally towards the skin, at the penultimate transverse band. Its commencement I have not been able to trace; it may possibly be connected with the double pipe of the head. Of its use, too, I am ignorant.

The muscles of the gizzard (I). To the upper part of each side of this organ is attached a stout muscle or tendinous cord (8, 8), which proceeds downward through the whole body, and is inserted in the skin near the foot-bulb. The action of these cords is powerful, sometimes dragging down the gizzard far into the abdomen: the action of either alone draws the top of the gizzard to one side.

The muscles of the occipital sac. Three bands (6, 6, 6) are attached near the bottom of this, which pass up on the two sides, and

along the back of it, and are inserted into the head. They draw the ganglion upward or to either side. To the lower part of the sac are attached two pairs of thick and strong muscular cords, which pass down to the hinder extremity of the body; one pair are fastened to the sides (10, 10), and the other pair (9, 9) somewhat on the ventral aspect of the sac; the latter are particularly stout and powerful. Their action is, doubtless, to draw back the sac into the trunk, an operation continually being performed, though I know not its object. Often in the sudden driving back of the sac, these stout strings are seen bent into a sigmoïd curve; this might seem to militate against their being muscles; but, I think, when thus bent, they are not in action, the whole fore parts being retracted by the contraction of other muscles.

Lateral longitudinal muscles (11, 11) are inserted into the head, and passing down each side are again inserted into the skin at the hindmost transverse band: these retract the skin.

Longitudinal muscles for the drawing in of the foot (12, 12). They are inserted into the skin of the neck on each side, and into the foot-bulb.

Diagonal foot-muscles (13, 13) inserted into the skin at the hindmost transverse band, and into the sides of the foot-bulb. Their use, in conjunction with the preceding, is to draw the foot-bulb to either side.

A pair of small muscles (15, 15) are attached to the extremity of the intestine (which is drawn in a dotted line) and to the skin of the projecting points of the anus. These are possibly mere ligaments to keep the intestine in its place, or may perhaps be merely the outline of a short rectum.

The foot (17) is partly sheathed in the foot-bulb (16) by a folding of the skin; it is drawn up to either side, by either of the foot-muscles (18, 18), or drawn in by both acting together.

The conical toes, somewhat flexible at the tips (19), are capable of independent action. They are separated by the contraction of a pair of muscles (20, 20), the expansors of the toes, and are brought together by that of the closers (21). These all have their anterior extremities inserted into the foot-bulb.

Besides these, the head-mass is attached to the skin by several muscles, five or six (or even more) on each side. When the head is much retracted, and the skin somewhat inverted, these muscles are seen at great length, inserted at different distances from the edge. Some of them are furcate, and are attached to the head-mass by two

points. The retraction of the parts is too rapid to allow these to be accurately copied.

Fig. D represents the left side of the animal. The abdominal viscera preclude any distinct sight of the muscles on the ventral region, but on the dorsal parts they are seen numerously. Many of those already described are recognisable, and are marked with the same numbers. There are some, however, additional; chiefly situate near the mesial line of the dorsum, perhaps not in pairs. One (23) proceeds from the back of the head to a point between the second and third transverse bands; where another (24) commences and reaches to the last transverse band. Of both, the insertions are in the skin, and the use is evidently longitudinal contraction. A band or cord (25) seems to proceed from the occipital sac to the middle of the back, between the third and fourth transverse band, and helps to draw it downward and backward. Above this are two cord-like organs, which, I think, are not muscles, but vessels, or perhaps nervous cords, issuing from the centre of the back of the ganglion, and jutting out into two arches, one above the other: the lower (26) I have not traced far, but the upper (27) runs down in a loose, tortuous manner for some short distance along the back, when I cease to discern it. It is this serpentine slackness which makes me doubt its muscular character. 28 is the great frontal tube of the ganglion, showing its forward curvature.

Such then are some of the details of the structure of this tiny animal; many of them I have observed also in other species and genera, which are possessed of organs of which this species is deprived. They prove that the minuteness of the animals of this class does not preclude them from having an organization most elaborate and complex; and, I think, justify the belief that the *Rotifera* occupy a place in the scale of animal life much higher than that which has been commonly assigned to them.

Of the manners of the species I have not much to say. In a phial it frequently clings to the sides of the glass, and appears sluggish; but when put into a live-box, it is active, especially if there be any *Conferva*, or leaves of *Chara*, or roots of *Lemna* in the water. Among these it crawls about nimbly and impatiently, like a caterpillar, pushing itself in every direction, by means of its two-toed foot, and by the elongation and contraction of its body; but without any definite course. The extent to which the fore parts are introverted is remarkable, the gizzard, as already observed, being sometimes made to touch the hinder part of the body. This action

is very frequently performed with a vigour that resembles the pumping of *Notommata syrinæ*. At the same time the body is made to assume various curves, and the integument is thrown into sharp angles. The foot is also occasionally drawn completely within the body by a similar action. The skin of the body, at several points, forms transverse infoldings, or telescopic joints, like the segments of a caterpillar, but less permanent.

It commonly keeps the ear-like lobes concealed while crawling; but will often suddenly protrude them, and in the same instant shoot off through the water with considerable rapidity, and with a smooth, gliding motion, partially revolving on the longitudinal axis as it proceeds.

Like most of the class, this *Notommata* is predatory. I once saw one eagerly nibbling at the contracted body of a sluggish *Rotifer vulgaris;* the mouth was drawn obliquely forwards (see B), and the jaws were protruded to the food so as to touch it. It did not appear, however, to do the *Rotifer* much damage. Another, which I kept for some days, I supplied with *Euglena viridis* in abundance; some of which it ate, for the stomach, which had been empty, became full of green masses. I once saw it devouring one; the jaws broke it into three or four morsels, which then passed through the duct behind, and were received into the stomach. I think it chiefly fed on *Monads*, which were numerous; for though I could not see any enter, it frequently used the vigorous syringe-like action, withdrawing the gizzard almost to the foot-base, and then the jaws worked for a while.

## EXPLANATION OF PLATE XII.

Fig. A. *Notommata aurita*, extended and rotating.
B. The same viewed laterally, contracted.

## EXPLANATION OF PLATE XV.

Fig. H. The nervous, respiratory, and part of the muscular systems. The principal viscera are omitted for the sake of perspicuity.
1, 1. The tortuous vessels.
2. The contractile bladder.
3. The tremulous respiratory tags.
4. One of these in more rapid action.
5. Bands of attachment.

Fig. I. The muscular system, viewed dorsally.
1. Tubular cavities in the head-mass.
2. Transverse muscular bands.
3. The bent lateral vessels (?).
4. The occipital sac.
5. The ganglionic mass.
6, 6, 6. Its anterior longitudinal muscles.
9, 9; 10, 10. Its two posterior muscles.
8, 8. The muscles for retracting the gizzard (7).
11, 11. Lateral longitudinal muscles.
12, 12. Longitudinal foot-muscles.
13, 13. Diagonal foot-muscles.
15, 15. Muscles of the rectum.
16. The foot-bulb. 17. The foot.
18, 18. The foot-muscles.
19, 19. The toes.
20, 20. The expansors. 21. The closers of the toes.

Fig. D. The muscular system, viewed laterally.
2 to 13. As in Fig. I.
23, 24. Longitudinal dorsal muscles.
25. Central cord of the occipital sac.
26, 27. Arching cords (or vessels ?) from the same.
28. The frontal tube of the ganglion.

Fig. G. The dental apparatus of the gizzard, as seen in action.

Fig. E. The same under pressure: the *mallei* resolved into bony loops: the floating muscular bands attached to the *mallei*, and to the table of the *incus*.

Fig. F. The same, under more powerful pressure: the arms or heads of the *mallei* resolved into hands of five fingers (1 and 3); the rods into loops (2); the *incus* into a bent spatulate foot (4), and two umbrella-like tables (5).

Fig. C. The appearance of the head when the ear-like lobes are inverted.

Fig. C.

Fig. E.

Fig. F.

Fig. D.

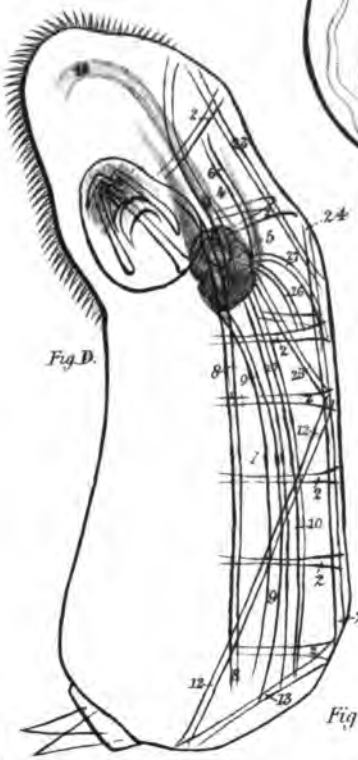


Fig. G.

Fig. H.

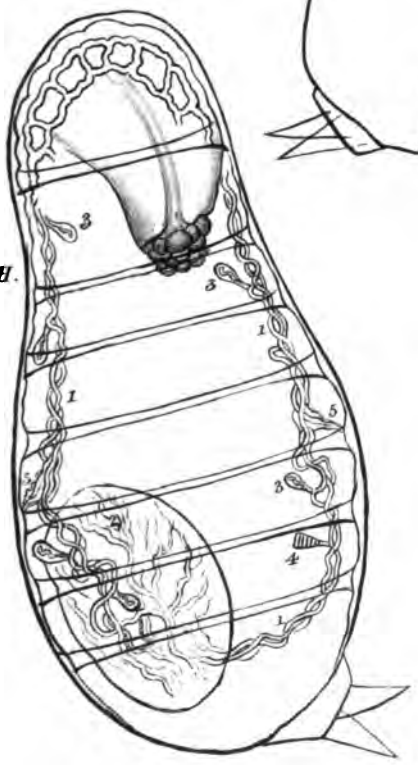
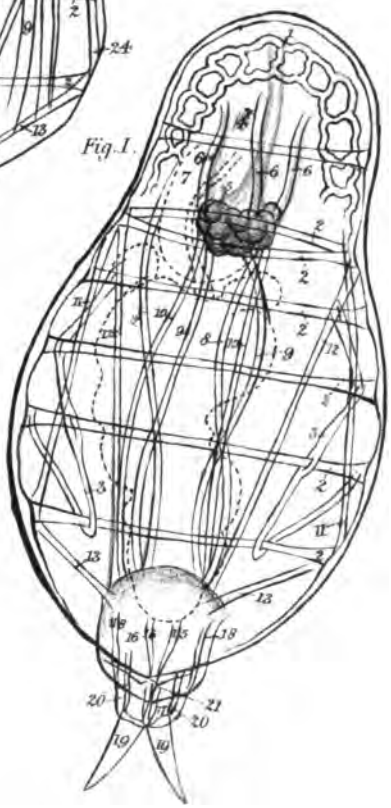


Fig. I.



PH Gosse del. S Leonard. lith.

Day & Son, Lith. to the Queen.

## XIX.—*On the Minute Structure of the Calcareous Shells of some Recent Species of Foraminifera.* By W. C. Williamson, Esq., Professor of Natural History in Owen's College, Manchester.

(Read at the meetings of June 12 and June 26, 1850).

Notwithstanding the large amount of attention that has been given to the study of the *Foraminifera* within the last few years, there is still very much of obscurity resting upon their history; wide differences of opinion existing both as to their true zoological position, and as to the objects to be comprehended in the group of animals so designated.

As the Microscopical Society has honoured me by the publication of my memoir on *Polystomella crispa* in their 'Transactions,' I have been led to hope that the monograph has contributed in some degree to the adoption of more accurate views as to the true nature of these organisms, and I have hence been encouraged to persevere in the inquiry. Accordingly I now lay before the Society the results of some investigations into the structure of these remarkable objects. It is my intention in the present memoir to confine my remarks to some peculiar forms, chiefly belonging to the three genera *Amphistegina*, *Orbiculina* and *Nonionina*, and to describe the structure of their calcareous shells, which throw a considerable amount of light upon those of *Nummulina* and *Orbitoides*, to which so much attention has recently been paid by Dr. Carpenter and Messrs. Jolie and Leymerie.

Through the kindness of Mr. James Samuels, of Manchester, recently a resident at Havannah, I have obtained some rich sand from that locality; sand, in the ordinary sense of the word, it is not, being almost wholly composed of calcareous granules, *Foraminifera*, spicula of sponges and *Gorgoniæ*, and abraded atoms derived from the disintegration of shells, corals and echinoderms; the whole being really a modern limestone deposit in the first stage of its formation.

Amongst other beautiful forms of *Foraminifera* found in this Cuban sand, are numerous specimens of the lenticular *Amphistegina gibbosa* of D'Orbigny. When viewed under the microscope as an opaque object, this species exhibits a smooth, white, glossy surface,

intersected by numerous bluish, translucent lines, which, though somewhat irregular in their external aspect, exhibit a disposition to radiation from the centre towards the circumference of each lateral half of the shell.

On making a horizontal section of this species at its greatest diameter, I obtained the appearance presented by fig. 1, Pl. 17; and on preparing a section in the opposite or vertical direction, its aspect was that of fig. 2. From the first of these we see that, in its principal features, this species exhibits the ordinary contour seen in so many of the *Foraminifera; viz.*, a spiral arrangement of cells, separated from each other by calcareous septa. Fig. 2 shows that the object is not only inequilateral, its inner convolutions especially being more convex on one surface than on the other, but that the convolutions are not all on one plane; the earliest formed spirals being on a lower level than those of a more recent growth. Hence it is impossible to make a horizontal section of this species, in which the incision shall pass through the middle of each convolution: some of them must be either above or below it. From this cause, fig. 1, which represents a section made in the direction of a line drawn from fig. 2, *a*, to 2, *a'*, passes above the median plane of the innermost convolutions; and hence the substance of the shell, being cut through obliquely, has at this point a somewhat different aspect to that of the outermost convolution.

In the arrangement of the septa, as seen in fig. 1, *Amphistegina* differs but little from the ordinary type of the rotuline forms; the septa being as usual, convex anteriorly and concave posteriorly; whilst above and below this median line the segments of the soft animal and their corresponding septa are prolonged in the direction of the centre of each lateral half of the organism. One aperture exists (1, *b*) in each septum, as in *Rotulina* and *Nonionina*, communicating between contiguous chambers, the septum being often thickened at that point, especially on its anterior surface. Excepting in the case of two or three of the septa, the section, in this instance, has not crossed the aperture, but passed a little above it.

This specimen exhibits the existence of numerous calcareous papillæ and projecting pillars, which are thickly dispersed over the inner floor of each cell (1, *c*) and the anterior surface of each septum (1, *c'*), but which do not exist on the posterior concave surface of the septa or on the glossy external parietes of the shell, excepting in the immediate vicinity of the oral orifice in the anterior septum of the shell. The fact that the greatest portion of the exterior is so

smooth and polished, shows that these calcareous papillæ are secondary growths deposited after the gelatinous segment has surrounded itself with a calcareous covering, thus proving that the creature has the power of strengthening its habitation by adding pillars and buttresses, which thicken its walls. At 1, *d*, where the section has cut the segments across near the union of the septum with the lateral parietes of the cell, we see that these papillæ become largely developed, shooting off from the septum like so many buttresses flanking the sides of an arched building. Since very few foramina pass through the external walls of the shell where these septa, with their flanking appendages, are united to them, we can trace the direction assumed by these latter portions, even on the exterior of the shell: they evidently produce the radiating lines which, by their translucent aspect, add so much to the beauty of its exterior.

As we trace the direction of the spiral outline, beginning at its external extremity, we find that the parietes become thickened as we proceed. In the central portion this appearance is partly caused by the oblique direction in which the section traverses it; but independent of this, there is, up to a certain point, a real increase of thickness, as is proved by a glance at the vertical section (fig. 2). Thus, though the section has traversed the organism in nearly the same plane at 1, *e*, and at 1, *a*, we observe that the thickness of the shell is much greater at the latter point than at the former. The probable explanation of this increase of thickness will be given after describing the next specimen.

Fig. 2 represents a section which I made at right angles to the former one, in the direction of a line drawn between the points fig. 1, *a* and *a'*. From this specimen we see that the parietes of the shell consist of a great number of minute parallel lamellæ, traversed in certain parts by long and well-defined tubes for the transmission of pseudopodia; whilst in other portions these tubes are wanting. The latter is especially the case in the central portion (2, *b*), corresponding with the umbilical region, or columella of a spiral mollusk, and at the angular external margin of each segment (2, *a* and *c*). In an occasional instance only (2, *d*), a few tubes traverse the latter portion of the organism.

In this section we again see the small calcareous papillæ (2, *e*) studding the floor of each chamber, whilst the internal surface of the outer wall is free from them, excepting where the oblique direction assumed by the septa brings the two together as at 2, *f* and *f'*.

Occasionally these calcareous appendages are so large as to constitute distinct pillars passing completely across the cell (2, *g*).

The peculiar points which distinguish the structure of this organism from that of any recent *Foraminifera* hitherto described, are the existence of the visible laminæ in the parietes of the shell (arranged at right angles to the direction assumed by the pseudopodian tubes), and the calcareous columns and small papillæ seen in the interior of each cell. The question to be next solved is, how have these peculiar features originated? At first I was disposed to believe that, after the segment had formed its calcareous covering, it possessed the power of thickening its walls by the deposition of concentric layers of calcareous matter to every part of its inner surface. Several difficulties, however, rendered this explanation unsatisfactory. First, the direction assumed by the lamellæ, as seen in the two sections, did not bear a sufficient relationship to the internal contour of each cell. Secondly, it was only legitimate to assume that if such successive *internal* growths had taken place, they would have occurred consentaneously throughout the entire organism; in which case the number of laminæ would have increased as we approached the centre of the organism. The result of this would have been, that the laminæ required to produce the thickness of the cell-wall, as seen at 2, *c'*, would have entirely blocked up the innermost cells of the animal. This, however, has not been done: the relative size of the cells and the thickness of their walls, as seen in the innermost and smallest convolutions, appear to be proportionate to the relative dimensions of the analogous parts in the more external and larger spirals.

A third difficulty arose from the arrangement of the pseudopodian tubes at the margins of the convolutions, as seen at 2, *a*, *c* and *c'*. At 2, *a*, we observe that the divergence of these tubes, which radiate from the interior of the cell in opposite directions, produces in the vertical section a small, triangular, translucent spot, of which the apex is directed towards the centre of the animal. In this translucent triangle the lines of growth are distinctly visible. At the opposite side of the specimen (2, *c*), which forms an older portion of the organism, we find that the increase in the thickness of the parietes of the cell has also led to a corresponding increase in the size of this triangular spot; but the enlargement is obviously at its base, or external portion, its internal apex being unchanged. The tubes, retaining their primitive direction, continue, of course, to diverge more and more as each addition of new layers produces their elongation, which would

not have been the case had the additions been made to the interior of the cell.

These facts led me to reject the first explanation that presented itself, and to conclude that by whatever instrumentality the new growths were formed, they were applied to the exterior, and not to the interior, of the organism. Another way of accounting for the facts still remained, and though rather startling, I believe it to be the true explanation. At 2, *i*, we find that the laminæ are consolidated into one compact mass; but on tracing the same lamellæ down to the point (2, *c*), we find that they separate into two divergent sets, some forming an inner septum (2, *b*, corresponding with that seen near fig. 1, *a'*), whilst the greater number constitute the outer shell-wall (2, *c*), with the narrowed posterior apex of a cell intervening between them. Thus we learn that the thickness of the parietes at 2, *i*, is at least owing to the contiguity and amalgamation of the laminated walls of two or more cells.

Connecting this fact with that of the exceeding thinness of the cell-wall of the last-formed cell (fig. 1, *h*), I have come to the conclusion that the greater thickness of the earlier and older growths of the shell is owing to the circumstance, that on the addition of each new segment the cell-wall by which it is enclosed has not terminated at the boundary of the individual segment itself, but has been prolonged over a considerable number, if not the whole, of the segments belonging to the outermost convolution of the animal.

But before this explanation can be received we require the admission of another proposition, *viz.*, that before the newly-formed segment enclosed itself within the limits of its own calcareous cell, it must have had the power of spreading itself out in the form of a thin gelatinous layer, investing the whole of the pre-existing organism.

Startling as I acknowledge this proposition to be, I see no other way of explaining the phenomena exhibited in this interesting species. In the horizontal section (fig. 1) I can easily trace the more external lamellæ, extending continuously along the spiral wall from *f* to *c*, covering once at least four chambers, and equal to nearly one-third of the entire convolution. This fact requires an extension of the soft animal, the secreting agent, at least proportionate to that of the result produced, and which is clearly not to be found in the circumscribed segments of the soft animal, so long as they are shut up within their calcareous cells: I can only conclude that in order to the production of such a result, the animal must have had the power either of leaving its cells to a considerable extent, or of

expanding its newly-formed segment to such a degree as to cover the organism with its thin gelatinous tissue. It must be borne in mind that such an investment would only require a *retral* expansion of the animal; the V-like form of each segment would enable it, in its normal state, to cover an area extending from one umbilical region to another, equal to that of its own diameter. Having so spread itself out as an investing body, it appears to have deposited new calcareous layers, covering over the greater part of the pre-existing external segments; but in each layer so added, open points have been left opposite to the mouths of the pseudopodian tubes in the layers previously formed; reminding us of the way in which similar apertures are left opposite the mouths of the canaliculi in membraniform bone-growths. In some instances, however, especially near the umbilical region, as seen in fig. 2, these tubes have been blocked up by the more recent investments.

After thus covering over at least a considerable part of the exterior of the shell with new lamellæ, the soft animal appears to have retreated to the limited area which the new segment was ultimately destined to occupy; and here the new lamellæ, continuously prolonged, instead of remaining in close contact with the pre-existing shell, have sprung up from its surface, in order to form a calcareous covering for the newly-formed segment, which would, in its turn, be invested and rendered denser by numerous repetitions of the same process. I can see no other way of explaining the growth of the smooth and glossy shells of *Amphistegina gibbosa*. The probability of its correctness is somewhat enhanced by an important fact, for the knowledge of which I am indebted to Professor E. Forbes. He remarks in a letter, "When dredging in the Shetlands six years ago, I took some good *Nodosariæ* alive; and after carefully watching them for a day, I saw the substance of one of them extended from the orifice in the form of moniliform strings of granular substance." This observation, made by such a distinguished naturalist, establishes the fact that these organisms can extend themselves beyond the limits of their calcareous cells, through the narrow apertures usually termed *oral*, and consequently makes it more probable that the soft animal of *Amphistegina* had the power of extending itself in a similar way; reminding us of the ordinary movements of the difflugian *Infusoria*. Supposing the above explanation to be correct, it still remains a question for investigation whether the entire animal has been able to leave its cell, or whether the expansion has only occurred to the budding segment prior to its having been enclosed

in a shelly covering. If the former should prove to have been the case,—if it should be found that the whole soft organism was able to squeeze its numerous segments through the equally numerous, constricted, oral passages,—it will be an additional evidence of the low organization of the group, inasmuch as we can scarcely conceive of anything in the shape of digestive canals and other concomitant appendages being subjected to such a compression as this with impunity.

There appears at the same time to be little doubt that the small calcareous papillæ and other projections seen in the interior of each cell, are additions which have been chiefly, if not wholly, made after the formation of the calcareous cell itself. Some of them exhibit traces of a laminated structure, and occasionally, as at 2, *e*, the pseudopodian tubes can be seen prolonged into and even through them. The greater number of the tubes, however, appear to be blocked up by this internal accretion of line; we especially observe this to be the case in the septa, as seen in the horizontal section (fig. 1, *g*), where the foramina, which originally penetrated the entire septum, as is still the case with that in front of the anterior chamber, are now seen to be arrested midway; the anterior half of each septum consisting of the secondary growths of calcareous matter, which they do not usually penetrate.

Fig. 3 reveals another new feature in the structure of the *Foraminifera*. It represents a small portion of the horizontal section of *Amphistegina Antillarum*. This species is more depressed than *A. gibbosa*, and also differs from it in the fact, that, in addition to the ordinary arrangement of the septa common to the genus, each cell or chamber in this species is subdivided into rhomboidal compartments by secondary septa arranged at nearly right angles to the primary ones. These subdivisions especially occur near the external or peripheral portion of each segment, which is the part represented in fig 3; *a* is the outer part of one of the primary septa; *b* and *b'* respectively represent some of the secondary ones. The latter appear to be sometimes complete, whilst at others they are but partial, having apparently an opening in the centre where the diaphragm has not been perfectly closed; but on this latter point I am not quite certain. Each of these septa exhibits the double structure which all recent observations indicate to be universal amongst the *Foraminifera*. Within these areas are seen the beautifully foraminated structures which constitute the lateral parietes of the shell. But the most curious feature in this species is found at the periphery of the horizontal

section, fig. 3, *c*, corresponding with the portion 2, *c*, in the vertical section. Here we find that the pseudopodian tubes are wanting, excepting in the innermost layers (3, *d*), where they are visible; but the outer layers, corresponding with the translucent triangular spaces (fig. 2, *c c'*) are perforated in every direction by a net-work of minute anastomosing canals, which communicate freely with the exterior of the shell, through numerous minute apertures. They also give off branches, which pass between the two layers of which each septum consists. As far as I can ascertain, however, these latter branches, though visible throughout the section, are most conspicuous at the points of junction, where the two divergent layers of each septum unite with the external parietes of the shell.

What special function these canals have been designed to fulfil, I am wholly unable to determine. The greater portion of the septa between which some of the branches pass, exhibit no traces of foramina; otherwise, we might regard them as being destined to bring an additional supply of aqueous fluid into contact with the internal soft organism. But where the thin adjacent parietes are so freely supplied with true pseudopodian tubes, it is difficult to conceive that any necessity exists for such a provision.

The next structure to which I would direct attention, is that found in what I believe to be an undescribed species of *Nonionina*. I am indebted to Mr. Matthew Marshall, of the Bank of England, for supplies of several beautiful sands, teeming with exquisite organisms. Amongst others, there was one from Manilla, which contained numbers of a fine form of *Nonionina*. In this shell all the septa are rendered distinctly visible externally by the marked contrast which exists between their solid, and consequently translucent texture, and the more opaque, yellowish-white parietal tissues, in which the foramina occur. Another feature characterizing the organism, and of which I had previously seen no recent example, was found in its thickened peripheral margin.

On making a vertical section, the instructive appearances represented by fig. 4 presented themselves. In the centre we find the primordial globular cell (4, *a*), apparently common to all the *Foraminifera*. On each side of this cell, we have the sections of three spiral convolutions; the outermost one on each side preserving an almost perfect transverse septum. The one to the left exhibits, at the point 4, *b*, the large central aperture of the *Nonioninæ;* in addition to which, we find a few very small and irregularly distributed perforations, which do not exist in the ordinary types of the genus.

In the parietes of this species we again find a lamellar structure, similar to that described as occurring in *Amphistegina gibbosa;* only owing to the circumstance that the convolutions do not embrace and enclose one another so completely in the *Nonionina* as in the *Amphistegina*, the former object does not show the great increase in the thickness of each umbilical region, which constitutes so peculiar a feature in the latter one: still, a large number of the lamellæ can be traced far beyond the permanent limits of the segment, of which they constitute the primary coverings, and are even seen to extend completely across the diameter of the shell. As in *Amphistegina*, they at least reach the centre of the organism, where they disappear amidst those which have come, in a similar manner, from the other side. This is a more remarkable circumstance even than that recorded in the case of *Amphistegina*. In the latter genus, as in *Polystomella* and many others, the newest convolutions completely embrace and enclose each other. In this Manilla shell, on the other hand, every convolution, from the centre to the circumference, is distinctly seen; and the outline of every septum, as already mentioned, is conspicuously visible.

The greater part of the shell is perforated with the usual pseudopodian tubes; but where the section has traversed any of the septa at right angles, or nearly so, we find that in the portions of the shell above and below each septum so divided, the tubes are wanting, producing the peculiar appearance seen at fig. 4, *d*. The absence of the foramina from these points has caused the laminated texture of the shell to be more obvious, and at the same time has rendered these parts of the organism more translucent than the rest; a condition which accords with that noticed to exist in *Amphistegina*, where the absence of the tubes produces a similar effect, modified only, as to the arrangement of the translucent portions, by the differences between the contours of the two objects. The real nature of this structure in the *Nonionina* is still better shown by fig. 5, which represents a small part of a vertical section made in a line parallel to that of fig. 4, only midway between the centre and the circumference of the object, so as to traverse at right angles the septa of the more external convolutions. Here we see that each septum is, as usual, double (5, *b*), and the pseudopodian tubes arising from the cells on each side of the septum at first converge as they ascend (5, *a*), and afterwards diverge as they approach the outer surface, thus leaving the translucent space

(5, *c*), which corresponds with the slightly raised line marking the direction of the septa on the exterior of the shell.

At the dilated external margin of each convolution (4, *e e*), the ordinary pseudopodian tubes suddenly disappear, giving place to a fan-shaped arrangement of larger radiating passages, which communicate between the outer angle of the cell and the exterior of the organism, and which occupy nearly half a circle. These tubes do not proceed at once to the margin, though such is their general direction; but under a high power, we find that they communicate with branches springing from them at right angles, and running in a direction parallel with the external outline of the organism. The orifices of these tubes are seen at 4, *e e*, divided transversely, when a magnifying power of 300 linear diameters is employed. Their direction will be still better comprehended from fig. 6, which represents a horizontal section of portions of two convolutions, with their transverse double septa. Those in the inner convolution (6, *a*) exhibit the ordinary appearance of these septa; whilst those of the outer one (6, *b*) exhibit an irregular variation in their distribution, which is not uncommon. In each of the spiral parietes (6, *c* and *d*) separating contiguous convolutions, we see at least one continuous tube, which sends off branches between the two layers of each septum. In the external margin of the outer convolution (6, *e*) corresponding with 4, *e'*, in the vertical section, we see that these circumferential tubes or canals are more numerous. They anastomose freely with each other, and communicate with large ones (fig. 6, *f*), crossing them at right angles; the latter being the same as those which produce the fan-like radiations (fig. 4, *c c'*). Many of the latter can be distinctly traced between the two layers forming the septa: where this cannot be done, in the case of the layer radiating canals, smaller branches given off from the anastomosing net-work are seen to be thus distributed.

Here we have evidently an analogous structure to that already seen in *Amphistegina Antillarum*, and doubtless serving the same purpose, whatever it may be. In this instance, however, we have, in the radiating canals, more definite evidence that one object of the structure is to bring the surrounding water into closer connexion with the interior of the animal than would otherwise be the case. The radiating canals (4, *e e'*) communicate directly between the exterior and interior of the cell. Whether or not any pseudopodia have escaped at these marginal apertures is doubtful, but I should be disposed to question the probability of their having followed the indi-

rect course of these canals, seeing that the same object could be attained in so much easier a way through the ordinary pseudopodian tubes. These anastomosing canals obviously maintain a free communication between the various parts of the comparatively thick shell.

Fig. 7 represents a superficial section of part of one of the lateral parietes of the same *Nonionina*, viewed as a transparent object. It exhibits the densely crowded foramina (seen also in portions of fig. 6), as well as the horizontal direction assumed by the translucent spaces (fig. 4, *d*, 5, *c*, and 7, *a*) surmounting the septa. These details appear to throw new light upon the structure of some species of *Nummulites*.

The next group, to the structure of which I would direct attention, is that comprehended in D'Orbigny's genus *Orbiculina*, including *O. complanata*, and previously designated *Orbitolites* and *Marginipora*. I have been much surprised to find that notwithstanding what has been accomplished by M. D'Orbigny in connexion with this group, it is still necessary to establish their affinity with the *Foraminifera*; many of the leading British zoologists continuing to regard them as true *Bryozoa*. That they belong to the former of these two families I have not the most remote doubt; their mode of growth, and the details of their internal structure, alike revealing their close alliance with the well-known *Orbiculina adunca*.

One of the most common species is the *O. complanata*. It not only occurs recent in the Mediterranean, in the Cuban seas, and in those surrounding the Philippine Islands, but is found in a fossil state in the foraminiferous marls of the *Calcaire Grossière*. A vertical section of this species is shown in fig. 8, of a portion of which section a still more highly magnified representation is given in fig. 9.

The central or primordial cell of this object is a large spherical cavity (fig. 8, *a*), partially separated from an adjoining one (8, *c*) by an imperfect intervening septum (8, *b*). The subsequently-added cells are arranged round these two as a central nucleus; at first they appear in oblique rows, and afterwards in concentric circles. In the vertical section, each cell right and left of the central point represents one of these rows and circles. The reason why there are more cells in fig. 8 to the left of the central point than to the right, arises from the circumstance that the early growths do not form complete circles, as is seen in fig. 10, shortly to be referred to more fully. The consequence of this arrangement is, that the primordial cell does not occupy the geometrical centre of the disk.

Fig. 9 gives an enlarged view of these cells, as seen in the vertical

section. They are single, undivided cavities (9, *a*), elongated vertically, and communicating laterally with the contiguous ones belonging to the same concentric row, by means of large central orifices (8, *d*, and 9, *b*, *d*). They also communicate with those which, though contiguous, belong to different circles, by means of similar orifices (9, *c*). The margin of each of these communicating orifices is usually thickened, and in frequent instances, as at 9, *d*, the orifice is not a mere aperture in the septum, but assumes a somewhat spiral or convoluted form, owing to the corkscrew-like twist given to the septum at this point. Fig. 10 represents a horizontal section of a central primordial cell of this species, with a few of its earliest additional growths. This example shows, what has already been alluded to, that the cells of the organism, when viewed in their superficial aspect, do not at once form complete concentric circles. In the specimen under consideration we observe, first the large cavity (10, *a*), then the second portion of the same (10, *b*), separated from *a* by the imperfect septum (10, *c*). Upon this is built another large, but complete cell (10, *d*), communicating with *b* by a single small aperture in the septum which divides them. We then have an additional row of four cells (10, *e e'*), nearly all of which communicate as before with the preceding cell (*d*) through corresponding apertures in the septum. In the next row (10, *f f'*) we have also four similar cells, and in the succeeding one (*g g'*) their number has increased to seven. Soon after the development of this row, the newer series has begun to bend round the point *g*, covering in succession the extremities of the cells *f'*, *e'* and *d*; whilst at their opposite portion (*g*) similar encroachments are made upon the periphery of the primordial cell, until at length, by the contact of the two extremities, complete concentric circles are formed, and continue to be so until the animal arrives at maturity. At the same time that they are thus arranged, they also observe the order seen in the disk of a *Coscinodiscus*, or the back of an engine-turned watch. The specimen (fig. 10) also shows us how irregularly the communicating apertures are distributed, though they are all arranged in the central plane of the organism. Sometimes they are isolated, as at *i*, merely connecting two adjacent cells together, belonging either to the same or to contiguous circles; at others they connect three such cells, two belonging to the same row, and one belonging to a more external series, as at 10, *k*. The latter appears to be the form seen in the vertical section at 9, *c*. From this cause the external margin of the disk has always exhibited a series of marginal apertures, whence the old name of *Marginipora*. I have not been able to detect any superficial orifices or pseu-

dopodian foramina in this object. The calcareous layer closing in each extremity of the cell, exhibits a very minutely-granular aspect, but I do not believe that it is perforated. This is no evidence, however, that the object is not a true *Foraminifer*. *Peneroplis lanatus* and many other well-established species exhibit precisely the same features in this respect.

Fig. 11 represents a vertical section of a remarkably fine species, belonging to the same genus, which, I believe, is as yet undescribed, unless it prove to be identical with the Australian form of which some sections are figured by Dr. Carpenter, in his memoir on the structure of *Nummulites* (Quarterly Journal of the Geol. Soc. of London). I am indebted to Mrs. Wilson, of York, the intelligent widow of a Wesleyan missionary who laboured amongst the Friendly Islands, in the South Seas, for several samples of sand from those remote shores. Though most of them were unusually devoid of organisms, one of them, from the island of Tonga, contained a rich supply of the most magnificent recent *Foraminifera* I had yet seen. If size and development are to be regarded as the test, the *Foraminifera* are retrograding: they appear to have culminated in the tertiary era, when the vast masses of Nummulitic limestones were in process of formation. The *Foraminifera*, thus represented, were giants when compared with their pigmy relations of the present epoch. Such having been my experience of their diminutive size, I was delighted to see in the sand from Tonga, specimens of an *Orbiculina* (*Orbitolites*) more than a quarter of an inch in diameter. It is a vertical section of one of these that is represented in fig. 11.*

In this section we observe the same general features as were noticed in the specimen fig. 8. In the centre we find four large cells, one of which (11, *a*) is probably the primordial one, being more globular than the rest. Right and left of these central cells we find the structure subdivided by numerous vertical partitions (11, *b*), separating corresponding intervening segments or cells (11, *c*). An enlarged and more definite representation of these structures is given in fig. 12; whilst in fig. 13 we have the appearance of the outer surface of parts of several concentric rows, exhibiting their external aspect. In the latter example the specimen has been partially ground away at the right-hand of the figure (*a*), in order to bring the details of a deeper structure better into view; the opposite side of the specimen retains its normal condition. From this

* See Appendix A.

latter portion we perceive that the species differs considerably from *O. complanata.* Instead of the surface exhibiting the closed extremities of a series of oblong cells, as in that species, we here find concentric rows of small oval fossæ or pits (12, *a*, and 13, *c*).* These fossæ are partially closed inferiorly by a rounded calcareous body (12, *b*, and 13, *d*), on each side of which are small circular apertures (12, *h*, and 13, *e*, *f*), communicating with the tissues below.

The enlarged representation (12) of the vertical section gives us the clew to all this. We see that the superficial fossæ do not correspond in their position with the subjacent cells, but are arranged in rows immediately above the septa which separate the respective circles of cells from one another; the upper surfaces of the septa constituting the bases (12, *b*, and 13, *d*) of the fossæ; whilst the two canals (12, *h*, and 13, *e*, *f*) communicate right and left with the contiguous cells belonging to two adjoining circles: the real external coverings of the cells are the calcareous portions represented by 12, *d*, and 13, *g*. We observe that all these structural details are repeated on the opposite surface of the disk (12, *e*).

On descending below the surface, and examining the interior of the organism, we find that it appears to present a very considerable amount of difference from the corresponding portions of *O. complanata* (fig. 9). A closer examination, however, will show that this difference is more apparent than real. The dark, shaded portions (12, *b b'*) are in reality nothing more than the septa dividing the cells (12, *g*), and correspond with the analogous septa, fig. 9, *e*. But in this species, instead of having only one canal connecting each cell with the contiguous one of an *adjoining* circle, as in fig. 9, *c*, we here have several (12, *c c*). And in a similar way, instead of having only one corresponding lateral communication connecting each cell with the contiguous ones in *the same* circle, as at 9, *b*, we here find a corresponding increase in their number (12, *f f'*). Thus the distinction between the internal structure of *O. complanata* and that from Tonga is merely such as arises from the multiplication of strictly analogous parts in the latter instance. I may remark with reference to the *lateral* apertures (fig. 12, *f f'*), that whilst the distribution of those which occupy the central portions of the organism (*f*) is exceedingly irregular, those which are nearest to each surface, (*f'*) and contiguous to the superficial fossæ, are just the reverse. In fig. 11 it will be seen that a row of them (*d*) may be readily traced round the entire circumference of the section. Thus we find that in

* See Appendix B.

every essential characteristic the structure of this Tongese specimen corresponds with that of *O. complanata;* the only real difference being the existence, in the former, of the concentric rows of superficial fossæ, and their small canals opening into the subjacent cells.

Fig. 14 teaches us that there is often a difference in the mode of growth, which also in some measure distinguishes the Tongese form. This figure represents a horizontal section of the primordial cell (14, *a* and *b*), corresponding with those seen in the vertical section (17, *a*), and analogous to those seen in *O. complanata* (fig. 10, *a* and *b*): it also exhibits the arrangement of the subsequent growths. The primordial cell (fig. 14, *a*), though more or less irregular in its form, is usually globular. This cell is surrounded by a still larger one (fig. 14, *b*), a communicating orifice always existing between them. Here too, as we observed in *O. complanata* (fig. 10, *c*), we often notice the existence of an imperfect rudimentary septum (14, *c*), partially dividing the outer of these chambers. In the case of the specimen represented at fig. 11, I suspect that the section has traversed one or two such septa, giving rise to the existence of three other large cells, to the right of that which appears to have been the primordial one fig. 11, *a*).

The outer cell-wall (14, *d*) of the large cavity has been perforated by a row of small apertures (14, *e*), in the same way that we found the outer septum of the cell (fig. 10, *d*) to present three similar canals, only in the former they are more numerous than in the latter, and surround the whole organism. From this stage we observe a considerable difference in the growth of the two species. Instead of increasing by slow degrees, and only after the development of many rows of cells, exhibiting one in the form of a complete circle, which we have seen to be the case in *O. complanata*, in the species from Tonga we very frequently obtain a similar circle at once, as if each cell had been the result of the simultaneous protrusion of a gemmule from every one of the apertures in the cell-wall (14, *e*). Though each of the small cells communicates, through these apertures, with the parent cell around which they are all arranged, I cannot succeed in detecting any lateral communication between the contiguous cells forming part of the same primary circle. Such lateral communications are frequent enough in the circles of cells formed when the organism attains to a more advanced stage of growth; but the individual cells of the first, and perhaps also of the second rows, appear to have no communication, excepting with the large cell which they surround, and with those of the circle by which, in their turn, they become surrounded.

After the formation of this first circle others are successively

added, until the organism attains to the large size already spoken of; those of a more recent growth differing only from the circles first formed, as stated above, in the existence of lateral channels of communication, corresponding with those seen in *O. complanata.*

When we compare the development of these *Orbiculinæ*, as now described, with that of other well-known *Foraminifera*, we see that although there are peculiarities attending the details of the former examples, yet they strictly conform to one general type. The existence to a central cell, more or less distinct from those by which it is succeded, has been previously shown, by both M. D'Orbigny and myself, to characterize nearly all the *Foraminifera*. On the other hand, I am unacquainted with any of the *Bryozoa* whose polypidom exhibits such a structure. However numerous may be the individual cells thus aggregated into one common polypidom, they are all exact repetitions one of another, excepting that amongst some of the *Escharæ* the calcareous cells of the older members of the group may be, as Milne-Edwards has shown, somewhat thicker than those of a younger growth; but there was no primary difference between the first cell enclosing the original germinal polype, and those which subsequently grew up around it. Thus we may legitimately conclude that whilst the structures represented in figs. 10 and 14 find no analogues amongst the polypidoms of the cilio-brachiate polypes, they do exhibit a close conformity with the typical contour which prevails amongst the true *Foraminifera*. That this is correct reasoning is, however, placed beyond a doubt by a comparison of the structures just described with that existing in *Orbiculina adunca*. This elegant *Foraminifer* has long been one of the best known of recent species. Very fair figures of it, both in its young and half-developed states, are given by Fichtel and Moll; the former bearing the name of *Nautilus angulatus*,* and the latter that of *N. aduncus*.† Excellent figures of some of its protean forms are also given in M. D'Orbigny's beautiful work on the *Foraminifera* of Cuba. In its young state it is one of the most abundant organisms in the Cuban sand. Fig. 15, which represents one of these immature forms, shows that it is at first a *Foraminifer* of the ordinary spiral type. Gradually, however, the posterior angles of the new segments, instead of continuing to be prolonged over the dorsum of the shell, as at fig. 15, *a*, begin to terminate more abruptly, as at fig. 15, *b*. This change becomes increasingly

* '*Testacea microscopica*,' &c., tab. 22. His *N. orbiculensis* is probably a variety of the same.

† *Idem*, tab. 23.

conspicuous as each new segment is added, since the angle 15, *b*, becoming recurved, verges towards the opposite portion of the corresponding segments at *c*, giving an increasingly reniform contour to the shell, in which condition it is the most frequently found. This process of growth will be readily understood on tracing the direction followed by the successive segments in fig. 16, which represents a specimen in which the process just described has gone on to such an extent, that not only have some of the segments met at *a*, but three or four of the outer ones are even completely cycloid, closely resembling those of *O. complanata* and the allied species from Tonga. Here we see a mode of growth in which all the leading features are identical with what we observed in *O. complanata* (fig. 11); only in the present example, instead of the convolutions being from the first spread out in one uniform plane, they are primarily embracing. In obedience to a general law which prevails amongst the *Foraminifera*, as illustrated by the genera *Spirolina*, *Cristellaria*, and others, *viz.*, that in their advancing growths they pass from a *more* to a *less* complex type, we find that the cells of the later and more external convolutions of *O. adunca* become spread out in one plane: towards the exterior of this species they are quite as much so as in the disks from Tonga. Thus we see that the cycloid form, which in the latter example is exhibited almost from the first, and which soon becomes the normal condition of *O. complanata*, is only attained in the case of *O. adunca* at a very advanced stage of growth: still, it *is* attained; the type is the same; the difference in the rate and extent of their development is merely one of degree.

On examining the internal structure of *O. adunca*, the existence of this affinity is thoroughly confirmed; but in comparing it with the other disks we must not select our illustration from the convoluted portion, though such a selection would bring us to the same conclusion. We must take a part of the organism where the other conditions are the same, and where the new segments are spread out in an uniform plane: fig. 17 represents a vertical section of such a portion, made in the direction of the dotted line 16, *b*, and traversing five of the outermost segments. On comparing this with the two vertical sections (figs. 9 and 12), we find that all these are constructed in conformity to a common type. The section is divided by vertical partitions or septa (17, *a*) into separate segments, which frequently communicate with each other through the open canals 17, *b*. Lateral communications also exist between various parts of the same segment, through the very large orifices 17, *c*, which are so large

that the septa thus dividing each segment into smaller compartments are little more than strong calcareous pillars. The segments are closed in above and below by the thin, shelly layers, 17, *d*, which are perforated by remarkably large pseudopodian foramina, and which have obviously answered the same end as the canals (fig. 12, *c*).

On making a horizontal section of a similar example a little below the level of the surface, we obtain the result delineated in fig. 18, in which portions of three concentric circles are shown. 18, *a*, *a'*, are the septa, separating contiguous segments, and correspond with 17, *a*, in the vertical section. 18, *b*, are the segments or vertical cells, if such they can here be called. 18, *c*, are open canals or orifices, corresponding with 17, *b*, and maintaining a communication between adjoining circles of cells. The analogous apertures, 18, *d*, correspond with the large passages, 17, *d*, and communicate laterally between the different subdivisions of the same circle. The vertical septa (17, *a*, and 18, *a*) are the most uniform in their contour; those which unite them together (17, *e*, and 18, *f*) having, as already observed, the character of thick, transversely-arranged pillars.

At 18, *e*, a portion of the external shell is visible, exhibiting the true pseudopodian apertures, which are larger in this species than in any other *Foraminifer* with which I am acquainted: we also see from this portion of the specimen, in which the section is ground very thin and close to the external shell, that whilst no foramina exist along the line of the concentric septa (18, *a'*), they are abundant opposite to the lines of transverse pillars (18, *f*), showing that the latter do not come in contact with the external shell, but always leave an open space between the two, which admits of a corresponding extension of the soft animal in immediate contact with the foraminated portion of the parietes. This is seen at 18, *e*, where, owing to the thinness of the section, these transverse pillars have been ground away.

On comparing the structures thus revealed to us with those existing in *O. complanata* and its Tongese ally, we cannot but be struck with their close resemblance to each other. The construction of the septa, the arrangement of the segments, and the distribution of the intraseptal canals, are as similar in the three cases as is compatible with the primary differences in their external forms. In the case of the intraseptal canals, the principal difference appears to be in their relative numbers. In *O. complanata* (fig. 9, *b* and *c*) we have but one series of orifices arranged in the median plane. In the Tongese

species, as well as in *O. adunca*, all the septa are pierced with them in considerable numbers. In the latter instance especially, the whole structure becomes little more than a convoluted shell enclosing a net-work of flattened, calcareous pillars, arranged at right angles to each other. Such close typical resemblances of structure and development as are here shown to exist, satisfy me as to the correctness of M. D'Orbigny's opinion, that *Orbiculina complanata* and its allies are true *Foraminifera*, and not *Zoophytes*.

In my memoir on *Polystomella crispa** I pointed out the existence in that species of a hard, central mass of translucent carbonate of lime, occupying each umbilical region, the surface of which was pitted by small depressions. I referred to these depressions as being probably the external orifices of canals communicating with the deeper and more central convolutions of the organism. I had not, however, been able to demonstrate the actual existence of such passages. In the same memoir I also referred to the difficulty of accounting for the external additions made to the surface of each calcareous mass, and suggested "that the central nucleus of lime may have been thickened through the instrumentality of the pseudopodia, which appear to penetrate it from the inner convolutions, and which, if this explanation prove to be correct, will thus possess an additional function to those already noticed. This, however, is a mere suggestion, arising from the difficulty of accounting for the appearance. The only other explanation which appears plausible, is, that the newly-formed segment, before enclosing itself in its calcareous cell, extends itself over the central nucleus, and there, gradually receding to what constitutes its permanent limit, leaves a calcareous layer behind it."

Vertical sections of *P. crispa* which I now possess, lead me to conclude that the latter of these explanations approaches nearest to the truth. We have seen that the structure of *Amphistegina gibbosa* could be accounted for in no other way, inasmuch as in that species no pseudopodia traverse the greater portion of each central nucleus, and consequently they could scarcely be the instruments employed in making the external additions. Fig. 19 represents the umbilical region from the upper half of a vertical section of *Polystomella crispa*. 19, *a*, is one of the internal cells near the centre, if not the primordial one, which I believe it to be. 19, *b*, are portions of cells belonging to successive convolutions. 19, *c*, are the small apertures

* 'Transactions of the Microscopical Society of London,' vol. ii. p. 170.

through which the connecting necks uniting the segments of the soft animal penetrate the septa; whilst the rows of larger circles (19, *d*) are the extremities of the cul-de-sacs into which the marginal processes of the soft animal are received. The central nucleus is penetrated by numerous large and somewhat irregular canals (19, *e*), which pass vertically from the surface of the organism towards its interior, terminating inferiorly, either as abrupt cul-de-sacs or tapering off to a conical apex. Not unfrequently these passages are seen to anastomose. Their internal surface is studded with a number of very minute, projecting points, but exhibit no other appearance of structure.

The intervening pillars of solid, calcareous substance (19, *f*) are seen to be very distinctly laminated; the laminæ being parallel to each other and somewhat arched upwards, resembling the similar lamellæ, which have been described in the preceding pages as existing in *Nonionina* and *Amphistegina*. The descending passages bear no relation to the position of the subjacent septa, neither do they in any instance pass through any of the chambers, in order to reach the more internal convolutions. They are strictly confined to the solid, umbilical region, and where the chambers commence they invariably terminate. All these points will serve to distinguish the passages from the anomalous portions of *Nummulina* and *Orbitoides*, which are regarded as such by Dr. Carpenter.* I have no doubt they are designed to facilitate the exit of the pseudopodia from those convolutions which would otherwise be closed in between the two lateral, calcareous nuclei. Guided by the additional light obtained from *Amphistegina*, I conclude that the laminæ seen in the vertical sections (19, *ff*), and which run parallel to the upper surface of the organism, have been formed according to the plan suggested in the case of the former example; which idea, as the preceding quotation has shown, is also in accordance with one of the two modes which I considered capable of explaining the structure when the previous memoir was written, though at that time I regarded it as the less probable of the two.

The *Rotalia Beccarii*, so common on our shores, also exhibits a peculiarity of structure which appears to involve the necessity for adopting a similar explanation of the way in which the *Foraminifera* make these external additions to their shells. Owing to the trochoid

* I believe that this preparation of *P. crispa*, along with the analogous ones, represented by figs. 4, 5 and 6, will be found to throw some valuable light upon these obscure but interesting forms, the elucidation of which is now in such able hands.

form of this species, its calcareous umbilical nucleus is restricted to the inferior side, where it is sometimes of considerable size. It exists in the youngest shells, being distinctly separated from the internal angles of the respective segments by a deep groove, and often projects beyond the level of the rest of the organism. As the latter increases in size the nucleus also continues to receive additions, and frequently subdivides, in the older shells, into three or four large, projecting tubercles. Smaller papillæ also stud the surface of the contiguous angles of the surrounding segments. In no instance have I succeeded in tracing the prolongation of pseudopodian tubes into the calcareous mass, though the other portions of the organism (excepting along the supraseptal spaces) are densely crowded with them; owing to the trochoid form of the shell all the segments, including even the primordial one, are brought into immediate connexion with the water from which they have drawn their nutriment.

The entire absence of pseudopodian tubes from the umbilical nucleus of this organism, renders the first of the explanations, originally suggested in the case of *O. crispa*, wholly untenable here. The second supposition appears to me to be the only one capable of accounting for this growth of *Rotalia Beccarii*. Any explanation that does not meet all the phenomena bearing on the subject will not satisfy the requirements of the case; but so far as the facts hitherto accumulated are concerned, the hypothesis which I have adopted in the case of *Amphistegina gibbosa* appears sufficient. As each new segment has been added to *Rotalia Beccarii*, the soft animal must have extended its slimy form across its inferior umbilical region, and thus added to the thickness of its nucleus, as well as to that of the small surrounding papillæ; and having done this, the segment has probably contracted itself within the limits which it was ultimately destined to occupy, and then encased itself in a special calcareous cell. Whilst in *Amphistegina* and *Polystomella* such external additions have been made alike to both sides of the object, in *R. Beccarii* they appear to have been chiefly, if not wholly, confined to the lower surface of the organism.

The details given in the preceding pages will have shown how desirable it is that the soft animals of *Orbiculina adunca* and *O. complanata* should be examined by competent observers: any intelligent individual visiting the shores of Cuba would have ample opportunities of doing this. Looking at the structure of the shell of the former species, and especially at the large orifices which communicate between its various cavities, we cannot fail to observe that it is a reticulated,

calcareous skeleton, whose proportionate relation to the size of the soft animal has differed but little from that borne by the siliceo-keratose net-work of many sponges to the slimy substance with which they are invested. The attempt to isolate the various portions of *O. adunca*, and raise each portion to the rank of an individual animal, even in the limited sense in which we should admit such a distinction in the polypes of a *Sertularia* or a *Gorgonia*, appears to me wholly inadmissible. If the soft structures of *Orbiculina* are as devoid of visible organization as are those of our British *Foraminifera*, and I have very little doubt that such will prove to be the case, the whole animal will be very little raised above the *Porifera*, only possessing a symmetrical, calcareous skeleton, which is at once both external and internal. In the former respect it of course differs from the ordinary forms of *Amorphozoa*.

I have recently found some frustules of minute *Diatomaceæ* (*Cocconeis*) in the interior of *Polystomella crispa*, which I had not succeeded in doing when the monograph on that species was written: none of these, however, are larger than could have been admitted through the orifices usually designated *oral*. Their distribution in the interior of the organism fully bears out my previously-published views as to the absence of any specially-located intestinal canal, either in *Polystomella*, *Rotalia*, *Rosalina*, *Planorbulina*, or the *Miliolæ*. I have very little doubt the soft animal will exhibit a like deficiency. Being in all probability a mere gelatinous net-work, interlaced through the meshes of a calcareous one, it is even still less likely to exhibit an alimentary canal, such as M. Ehrenberg thinks he has seen in some recent species, than the symmetrical segments of a *Rosalina* or a *Polystomella*. No other observers appear as yet to have detected such a canal amongst the *Foraminifera;* consequently it is desirable that zoologists should cease to perpetuate the idea of its existence until some more conclusive evidence respecting it be brought forward.

*Addendum to the foregoing Paper.*

*Appendix* A.—Since the preceding pages were penned, my friend Dr. Baird, of the British Museum, the enlightened historian of the British Entomostraca, has shown me two or three specimens brought by Sir Edward Belcher from Borneo, which appear to belong to this group of the *Foraminifera*. One of these was two inches and a quarter in diameter, reminding us of the splendid specimen of *Orbitoides* brought from Alabama by Sir Charles Lyell. Some of Mr. Jukes' Australian specimens in the possession of Dr. Carpenter are half an inch in width: these, however, are but the exceptions; as a rule, the recent species are of diminutive size when compared with the magnificent forms characterizing the rocks of the Nummulitic era, both in the old and new worlds.

*Appendix* B.— Through the kindness of Dr. Carpenter I have been enabled to compare my specimens with those of Mr. Jukes. In these most of the superficial fossæ are covered over by a thin film of calcareous substance, as is the case with the cells of *Orbiculina adunca*. This circumstance has led me to re-examine my Tongese specimens; and I find that though they are almost all in the condition described in the text, and delineated in figs. 12 and 13, here and there traces of a similar calcareous film may be detected; showing that its presence constitutes the normal condition. Its disappearance has apparently resulted from mechanical influences of the surf beating upon the shore, since in the Tongese examples the differences of age and size do not appear to affect the existence or otherwise of this superficial covering of the fossæ.

*February* 27, 1851.

## EXPLANATION OF PLATE XVII.

Fig. 1. Horizontal section of *Amphistegina gibbosa;* magnified 76 diameters. P. 106.
2. Vertical section of the same, made through the centre of the object.
3. Small portion of the external margin of a horizontal section of *Amphistegina Antillarum;* magnified 170 diameters. P. 111.
4. Vertical section of a *Nonionina* from the Philippine Islands; magnified 45 diameters. P. 112.
5. Vertical section of a small portion of the same species; magnified 160 diameters.
6. Horizontal section of portions of two convolutions of the same species; magnified 54 diameters.
7. Horizontal section of part of the external parietes, viewed by transmitted light as a transparent object, and showing the translucent, supraseptal spaces (*a*).
8. Vertical section of *Orbiculina* (*Orbitolites*) *complanata* from the Philippine Islands; magnified 70 diameters. P. 115.

## EXPLANATION OF PLATE XVIII.

Fig. 9. Portion of the same section, still more highly magnified.
10. Horizontal section of the same species, showing the primordial cell and some of the early additional growths; magnified 100 diameters. P. 115.
11. Vertical section of an undescribed species of *Orbiculina* from Tonga (Friendly Islands); magnified 20 diameters. P. 117.
12. Portion of the same section; magnified 100 diameters.
13. External surface of a portion of the same, showing the superficial fossæ. The part to the right hand (*b*) of the figure is in its normal state. On the opposite side (*a*) the surface is slightly ground down, in order to reveal the conformation of the base of each fossa. Magnified 140 diameters.
14. Horizontal section of the central primordial cell of the same species, with its early additional growths; magnified 60 diameters. P. 119.
15. Young state of *Orbiculina adunca*, viewed by reflected light; magnified 20 diameters. P. 120.
16. Similar representation of a matured individual of the same species from Cuba; magnified 20 diameters. P. 121.
17. Vertical section of a portion of the same species, made along the line *b* (fig. 16); magnified 160 diameters. P. 121.
18. Superficial horizontal section of the same portion, viewed from within; magnified 170 diameters. P. 122.
19. Vertical section of one umbilical region of *Polystomella crispa*, viewed by transmitted light, as a transparent object. Its inferior border descends a little lower than the median plane of the organism. Magnified 100 diameters. P. 123.

Fig. 1.

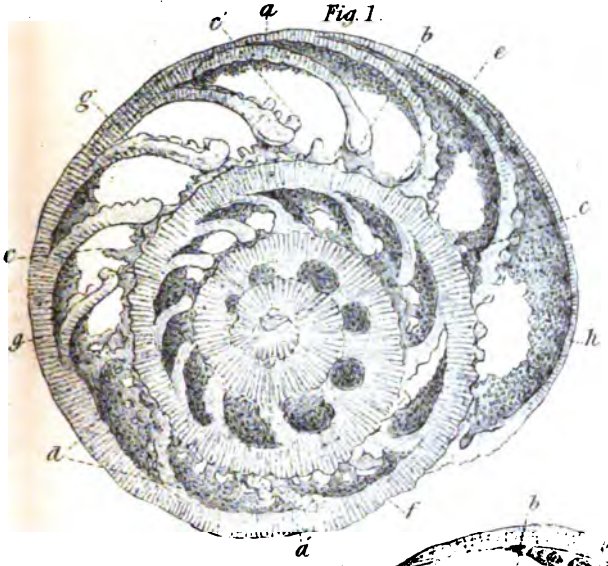


Fig. 3.

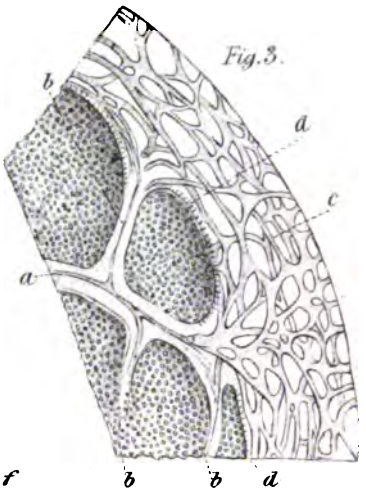


Fig. 2.

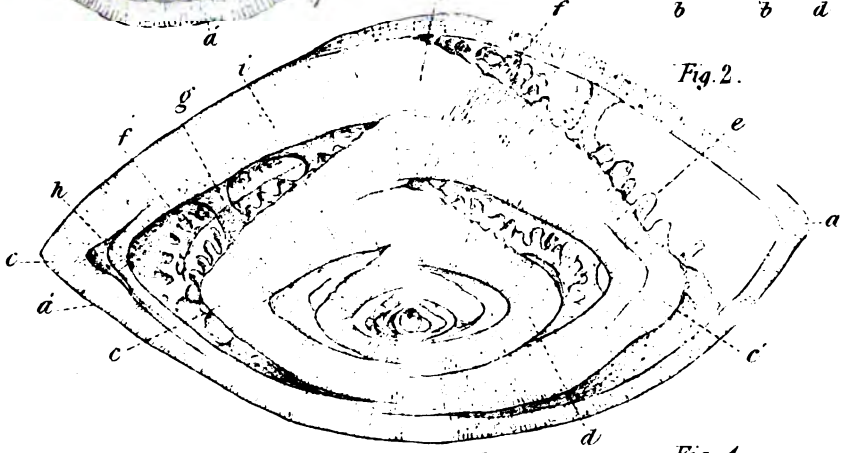


Fig. 4.

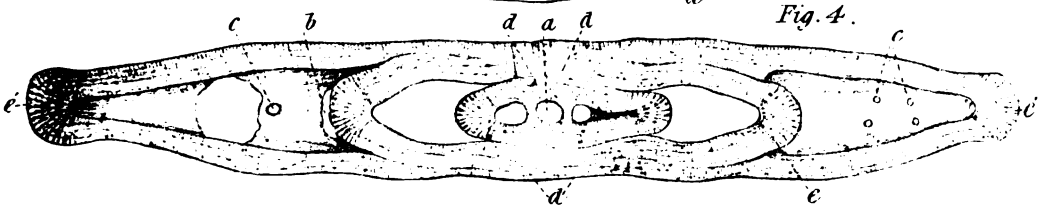


Fig. 5.

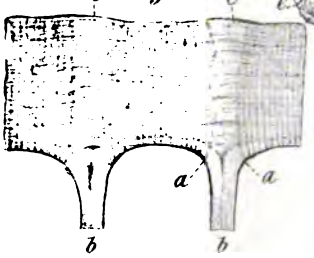


Fig. 6.

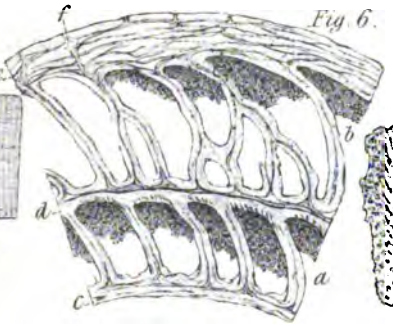


Fig. 7.

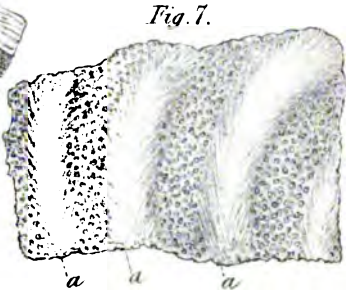


Fig. 8

W. C. W. del. Lens Aldous. lith.

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calcareous skeleton, whose proportionate relation to the size of the soft animal has differed but little from that borne by the siliceo-kerateose net-work of many sponges to the slimy substance with which they are invested. The attempt to isolate the various portions of *O. adunca*, and raise each portion to the rank of an individual animal, even in the limited sense in which we should admit such a distinction in the polypes of a *Sertularia* or a *Gorgonia*, appears to me wholly inadmissible. If the soft structures of *Orbiculina* are as devoid of visible organization as are those of our British *Foraminifera*, and I have very little doubt that such will prove to be the case, the whole animal will be very little raised above the *Porifera*, only possessing a symmetrical calcareous skeleton, which is at once both external and internal. In the former respect it of course differs from the ordi-

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## *Addendum to the [illegible]*

*Appendix* A.—Since the preceding [illegible] Dr. Baird, of the British Museum, the [illegible] British Entomostraca, has shown me [illegible] brought by Sir Edward Belcher from [illegible] belong to this group of the *F[illegible]* inches and a quarter in diameter, [illegible] cimen of *Orbitoides* brought from Alabama by [illegible] Some of Mr. Jukes' Australian specimens in the [illegible] Carpenter are half an inch in width; these [illegible] exceptions; as a rule, the recent species are [illegible] when compared with the magnificent forms [illegible] of the Nummulitic era, both in the old and new [illegible]

*Appendix* B.—Through the kindness of Dr. Carpenter I have been enabled to compare my specimens with those of Mr. Jukes. In these most of the superficial fossæ are [illegible] film of calcareous substance, as is the case with the [illegible] *culina adunca*. This circumstance has led me to [illegible] Tongese specimens; and I find that in such they are [illegible] the condition described in the text, and [illegible] here and there traces of a similar calcareous film may be [illegible] showing that its presence constitutes the [illegible] appearance has apparently resulted from [illegible] surf beating upon the shore, since in the [illegible] ferences of age and size do not appear to affect the [illegible] otherwise of this superficial covering of the [illegible]

*February* 27, 1851.

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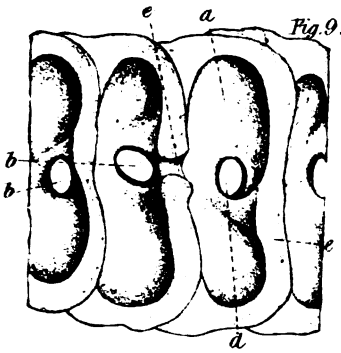
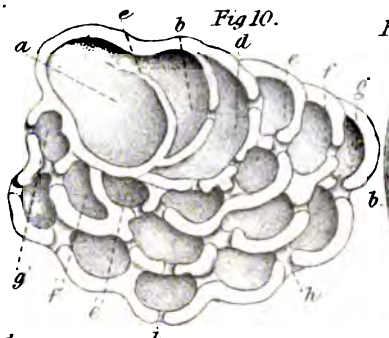
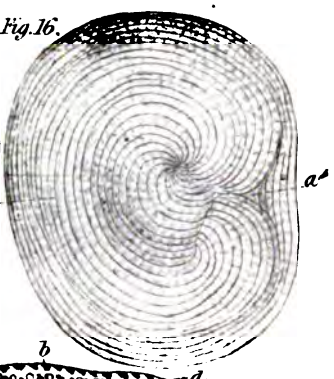
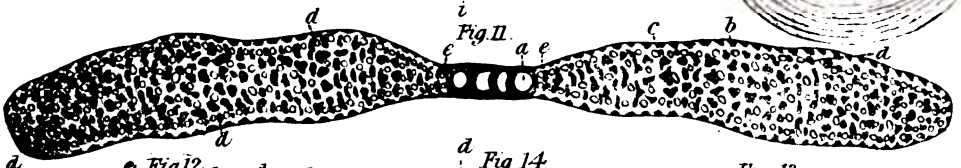
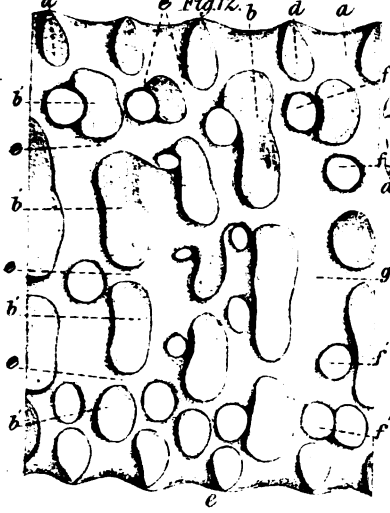
to The Queen

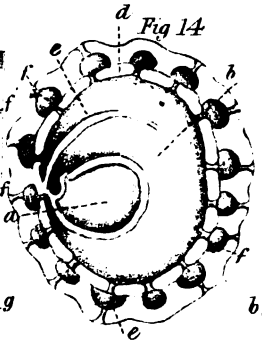


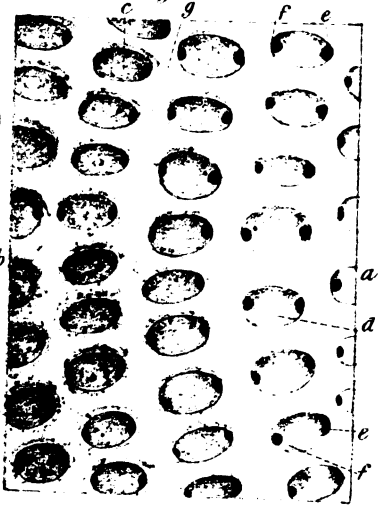



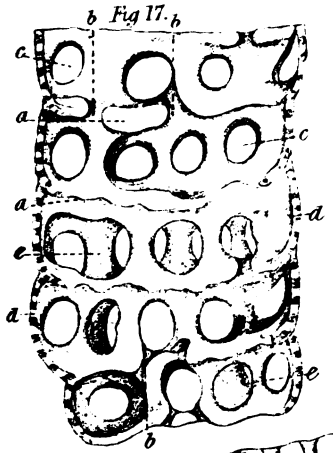



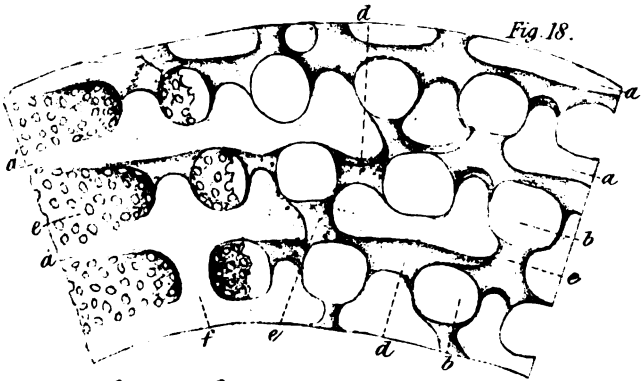



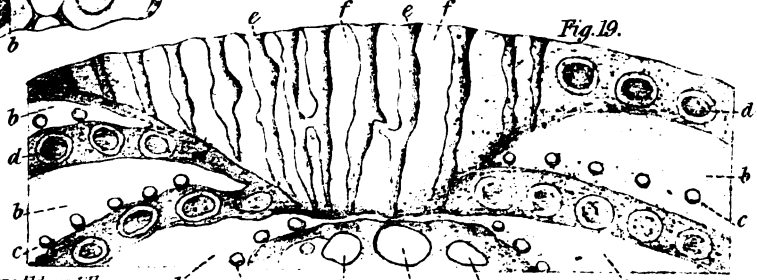



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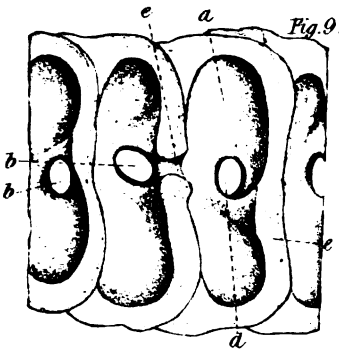
## XX.—*On the Occurrence of Parasitic Rotifera in Volvox globator.*

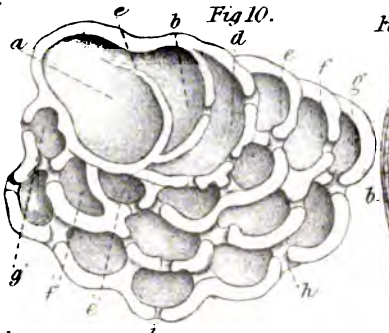
By Mr. John Williams, Assistant Secretary.

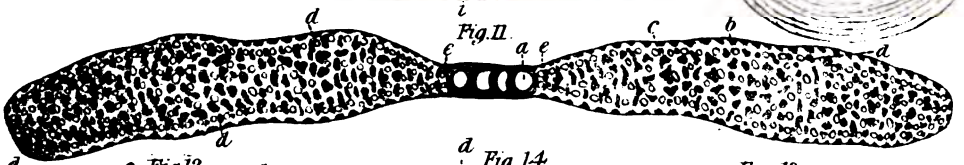
(Read June 26, 1850).

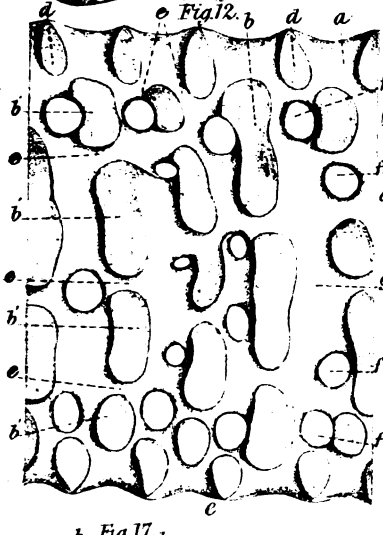
Ehrenberg, in his fourth figure of *Volvox globator*, represents one having within it a parasitic *Rotifer*, which he calls *Notomata petromyzon;* and in his fiftieth plate, describing *Notomata parasita*, he figures the same as occurring within *Volvox globator*. With these exceptions, I have not hitherto met with any account or figure of parasites within that animalcule, and as a case occurred to me since the last meeting, I am induced to lay an account of it before the Society, considering, that although these appearances have been observed before, still, as they are comparatively of rare occurrence, a well-authenticated observation of so extraordinary a fact might be of some value, as well as of interest to the members of the Society.

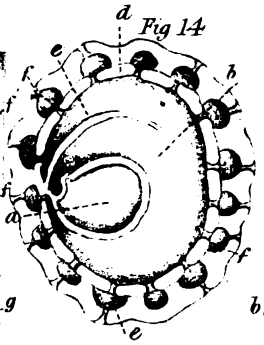
At the meeting of June the 12th I was supplied, by the kindness of Mr. Rosling and Mr. Ingpen, with some water containing numerous specimens of *Volvox globator*. The next evening, on examining some of these in a live-box, my attention was drawn to one of considerable size, within which appeared a large animalcule moving about with much activity, having the appearance of one of the *Rotifera*, and which I have no doubt was *Notomata parasita*. In length it was about one-third of the diameter of the *Volvox*, and its breadth might be about one-eighth. The *Volvox* presented the usual granular green spots, with five of those larger agglomerations of granules commonly seen in this creature. It was evidently living, as it not only moved about in the usual manner, but small bodies which came near to its edge were driven away with great velocity. There was also within it a fixed mass of gelatinous matter of irregular shape, in which at times I fancied I saw ciliary movements, but they were so indefinite, that I was by no means certain of the fact; in other respects this mass was perfectly motionless. As these appearances seemed to be something unusual, I was careful not to disturb the arrangement, and left everything as it was until the next

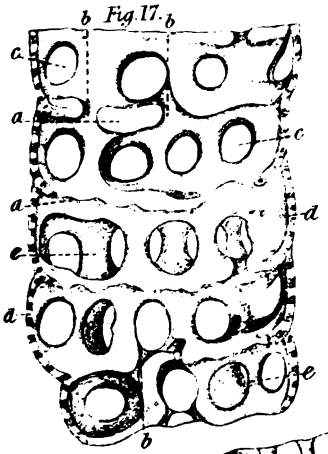


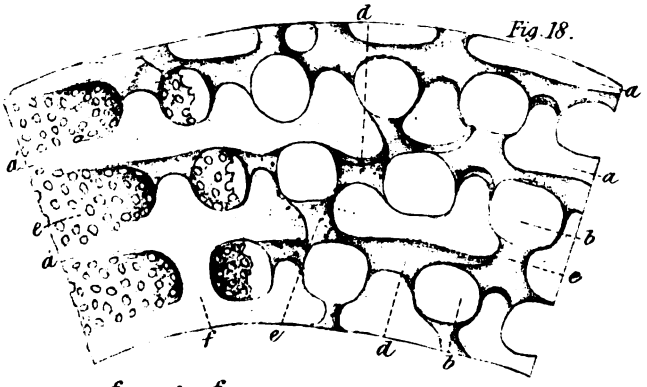



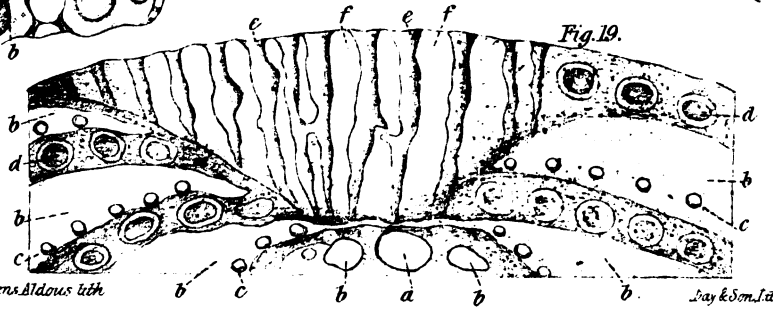


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## XXI.—*The Annular Condenser for the Microscope, a New Instrument, Contrived and Described by* GEORGE SHADBOLT, Esq.

(Read June 26, 1850.)

THE attention of the members of this Society having been several times of late directed to the consideration of oblique illumination, I am desirous of submitting on this, the last occasion before the recess, a description of a new instrument I have contrived for the above-mentioned purpose. I would premise that it is not intended to supersede any apparatus at present in use, but simply to be made use of as an additional tool for facilitating the acquisition of a knowledge of the structure of some classes of objects. I think it requisite to make this statement, as a notion appears to exist amongst some of our members that the various pieces of apparatus lately described are designed by their advocates to displace others in *all* cases, whereas this is very far from being the case.

To a gentleman who has been very recently elected a member of the Microscopical Society, Mr. Wenham, we are indebted for the idea of throwing the light obliquely from every azimuth of the circle at the same time, as illustrated in his parabolic condenser; and it was from viewing the effects produced by that instrument that I was led to devise the one I am about to describe. In remarking upon what I may consider slight disadvantages in the parabolic condenser, I cannot too strongly disavow any intentional spirit of detraction; for, indeed, I entertain a very highly favorable opinion of its utility; this, however, should not prevent any attempts at simplification or improvement, or deter from the endeavour to effect a similar object by other means.

In examining the parabolic condenser, there were three points which struck me as being worth an effort to amend. In the first place, all the rays do not fall on the object at the same angle. Secondly, the most valuable part of the parabola is necessarily cut off, and the rays that are reflected from the remaining portion can none of them be incident upon it at an angle of less than fifty degrees from the perpendicular; consequently a very large amount of the incident light is lost without reflection. Thirdly, the construction of a parabola correct in figure is by no means an easy operation.

To obviate these objections was my intention in devising the

annular condenser, and by the assistance of Dr. Southby, who most kindly constructed one in conformity with my suggestions, I have been enabled partially to put my theoretical views to the test of experiment. Messrs. Smith and Beck have also since constructed me one of these instruments, both of which I purpose exhibiting this evening.

The annular condenser consists of a ring of glass (hence the name), which, if cut across in a vertical direction, passing through the axis, would exhibit at the two sections a plane more or less triangular, consequently similar to a ring made of a triangular piece of metal, so that one of the planes is at right angles to the axis. The other two planes vary according to the desired obliquity of the light, but always so that the upper one nearest to the axis shall be at right angles to the emergent rays, as the lower one is to the incident ones. This ring of glass is fitted into a cell of brass, which screws into the ordinary fitting of the achromatic condenser instead of the lenses.

By this arrangement all the rays fall at the same angle, and in every azimuth of the circle; the reflection from the only surface required to reflect the light is very perfect, owing to the peculiar property of the internal reflection of light in dense media, referred to in a previous paper; and lastly, there is comparatively but little difficulty in the construction.

I regret that want of time has prevented my being able to carry out the principle as far as I could wish: the only instrument I have as yet been able to procure was not in my possession until late last evening, and it causes the light to fall at an obliquity of no less than sixty degrees, which is far too great for the larger number of objects. It appears, however, admirably suited for examining some of the so-called *Infusoria* when mounted dry, as also cuticular appendages in a similar condition, thin sections of bone, &c.

I omitted to mention that the width of the planes will be found most convenient if about the tenth of an inch.

*Addendum to the foregoing Paper.*

THE only difficulty in making such a ring of glass as above described consists in the polishing, so as to leave it free from lines. The method I suggested, and which was applied to the making of those that have already been constructed, was to apply the side of a tool by means of a slide-rest, placed at the requisite angles, and to keep the tool in constant motion to and fro during the revolution of the glass ring in the lathe, by which means a very tolerable polish has been produced.

This condenser may be made to give any one inclination to the ray, even to as near 90° as can be made to pass through the glass on which the object is placed.

Having determined what angle the condenser under consideration is to be constructed for, let the slide-rest be arranged so that the outer cone will be inclined to the perpendicular, half the angle of the required inclination, and the inner cone inclined to the base, double the preceding angle, that is, equal to the angle of the emergent ray.

Fig. 1*, plate XIV., shows the appearance that would be presented by cutting the glass part of the annular condenser in half. Fig. 2* is a perspective and fig. 3* a sectional view of the condenser in its fitting of brass, *a* being the glass ring, *b* the reflecting surface, and *c* any opaque substance, such as black wax, gutta percha, &c.

## XXII.—*On the Femoral Plates or Scales of the Zootoca vivipara.*

By J. B. Spencer, Esq.

(Read January 15, 1851).

In a work published some time since, a 'History of British Reptiles,' by Professor Bell, a description is given of our two indigenous lizards, *Lacerta agilis* and *Zootoca vivipara;* the former being a beautiful reptile, more scarce than the latter, which is the brown lizard of our heaths and commons; they are both characterized by being covered with scales or plates, varying greatly in size and shape, some of them possessing a very curious structure, which I propose to treat of in the present paper. The femoral plates or pores described by Professor Bell, occur in a single row, upon the under surface of each lower leg, running in the direction of its axis, usually from ten to twelve in number; I will quote their description from the work before-mentioned: — "The femoral pores, as they are termed, exist also in all the family; they consist probably of very small follicular glands, each placed in a scale, the middle of which is pierced by the opening of the follicle. In some the scale is very little larger than the pore, and appears almost like a minute tube: in others the scale is larger and triangular; the use of these pores is not known." In consequence of this latter statement, I was induced, last autumn, to obtain some of these active little creatures, the *Zootoca vivipara*, or common brown lizard, with a view to discover the uses of these pores or plates. Upon examination with a sufficient power I failed to realize the description of them given by Professor Bell; no perforation could be found: on the contrary, the surface of the femoral plates was produced into a semi-transparent process or horn of a light yellow colour, differing in this respect from the rest of the plate, and not possessing any discoverable perforations whatever. The average diameter of the plates is about $\frac{1}{50}$th of an inch, the processes or horny parts varying from $\frac{1}{100}$th to $\frac{2}{100}$th of an inch. Some care is required in catching these very active little creatures, for if any undue force is used, the processes above-mentioned become broken or rubbed off, leaving the hollow cavity of the plate exposed, and they then put on the appearance of perforations or pores, and fully agree with the Professor's description of them. Upon examining still further the internal structure of the

plates, I could not perceive any secreting vessels or glandular structure within them, and therefore conclude that they serve some other purpose than that of secretion. They may possibly serve (and their shape favours the idea) to give the creature a greater mechanical power of adhesion in certain cases; and this view of the case has been strengthened by the opinion of a very competent authority. I have made a rough drawing (Pl. XI. fig. 6), to give some idea of the size and position of the plates, and have also mounted the skin of the leg, showing the plates *in situ*, for the inspection of those members who may be inclined to examine them. A perfect plate is represented by *a*, fig. 7, and another in which the plate has been removed by *b*, in the same figure.

## XXIII.—*On the Scales of the Viviparous Blenny* (Zoarcus viviparus).

By John Quekett, Esq.

(Read January 15, 1851.)

Mr. Spencer's observations on the femoral plates of *Zootoca vivipara*, have brought to my remembrance some notes made about ten years since on the structure of the skin of the viviparous blenny, in which I found that certain spots which had been described as circular depressions were in reality scales; and curiously enough, the description to which allusion has been made, occurs in another of Mr. Van Voorst's series of works on Natural History, *viz.*, Mr. Yarrell's 'History of British Fishes.' In speaking of the skin of this fish, Mr. Yarrell states that "the surface of the body appears under a lens to be studded with circular depressions." I found, however, on microscopic examination, that these circular depressions, which are always of a white colour, were due to the presence of small, round scales, about one-twelfth of an inch in diameter, each having a minute spot in the centre; each scale, as shown in Plate XI. fig. 8, *a*, *b*, *c*, exhibiting concentric and radiating markings. The scales are situated deep in the cuticle, like those of the eel, and in some situations occur at tolerably regular distances apart, but are rarely nearer together than the twentieth of an inch.

## XXIV.—*On Ciliary Action in the Spongiadeæ.*

By J. S. Bowerbank, Esq., F.R.S., &c.

(Read November 13, 1850).

Although so many years have elapsed since Dr. Grant described the ciliated gemmules of *Halichondria panicea*, and demonstrated the existence of continuous currents of water from the great ex-current oscula of more than one species of the same genus; and although it has grown into an almost universal belief among naturalists, that the currents must be the result of ciliary action; still the existence of these important organs in the *Spongiadeæ* had never been clearly demonstrated, even with all the additional aid afforded by the modern improvements of the microscope. I had long felt this to be an opprobium to naturalists, and had determined, on the first convenient opportunity, to endeavour to solve the problem; when, in the course of the summer of the present year, I received a letter from my friend Dr. Johnston, of Berwick-on-Tweed, in which he mentioned that Dr. Dobie had succeeded in seeing the cilia in the *Spongiadeæ*. Stimulated by this information, I determined that in the autumn I would locate myself at Tenby, in South Wales, and follow out the investigation; and with a view of preparing myself for the work, I requested my friend Dr. Johnston to put me in communication with Dr. Dobie, to whom I wrote on the 13th of September. On the 27th of the same month I received a reply, from which the following is an extract:—"In February last I was residing for a short time near Berwick-on-Tweed; and, though quite ignorant of species of sponges, I determined to examine carefully any specimens I could pick up, with reference to the existence of cilia. I found a species of *Halichondria* very abundant, but, after repeated examinations, failed to discover these organs. In a species of *Grantia* I was more fortunate, having picked up several individuals in which vigorous currents were in operation. I slit up a specimen, and removed a little of the gelatinous matter lining the inner surface. This I examined with a ¼-inch lens. The field of view was crowded with the

oval particles, in a state of independent motion, single and in masses. The resemblance the movements of the single particles bore to the peculiar motions of the more minute monads which I have been in the habit of examining, at once convinced me that cilia were present, if I could but see them. With a fresh supply of the granules, covered with a piece of very thin glass ($\frac{1}{170}$th of an inch), I proceeded to a more strict scrutiny, using a very fine $\frac{1}{8}$ lens (Smith and Beck), and with the most careful adjustment regarding light &c. With this power I distinctly saw the individual cilia, slowly lashing and of extreme tenuity. I repeated the examination several times, with the same result. I should say that it is almost impossible to see the cilia with a lens lower than $\frac{1}{8}$ in."

"The appearance of the cilia was exactly similar to that represented in Plate III. fig. 19, b, of Dujardin's work on the *Infusoria*."

From the description given by Dr. Dobie I have little doubt that the species alluded to was *Grantia compressa*.

I had previously to receiving this letter commenced, on the 7th of September, my investigation, with a determination, in the first place, to observe both the in-current and ex-current streams of water, and to endeavour to trace the latter from the mouth of the sacculated sponge inward, if possible, to the source of the motion of the fluid. I selected specimens of the sponge not exceeding about a quarter of an inch in length; and on placing one of them beneath the microscope, in a closed cell, after a short time the ex-current action commenced, and continued steadily flowing for a considerable period, ejecting the fecal matter with much force. On examining the exterior of the same specimen, the in-current action over the whole surface of the sponge was equally well, though less forcibly, demonstrated. The floating particles in the water, when within the action of the in-current orifices, were at first slowly, but afterwards rapidly, drawn towards the sponge, and the action was similar over the whole of its surface, some descending on to the upper part of the surface of the sponge, while others ascended to the lower part, with about an equal degree of force. The fluid does not appear to enter the sponge by well-defined or regular orifices, but to pass, by numerous irregular pores, through the surface between the outer layer of the spicula.

Having thus seen the continuous entrance and exit of the surrounding fluid, I proceeded to an examination of the great saccular cavity, by carefully opening the sponge from the mouth to the base, through the compressed edges of the sac, with a fine pair of scissors, and mounting the halves of the sponge, with the inner surface

towards the eye, in a closed cell, as before. When thus viewed with a quarter-inch combination, the sponge is seen to be composed of angular cavities constructed of tri-radiate calcareous spicula, (Pl. XIX. fig. 2). They are closely packed together, like the cells of a honeycomb. The cavities are of the same diameter downwards for about the length of half their own diameter, and then they terminate in a perforated diaphragm, the circular mouth of which is of about half the diameter of the space above it, (Pl. XIX. fig. 2). Beneath this diaphragm there is an elongated cavity, or cell, the dome of which, crowned by the diaphragm, is lined with tessellated cellular structure, but which does not appear at the opposite extremity of the cavity, or that in which the in-current orifices exist.

The tessellated cells on the inner surface of the diaphragm are disposed in lines, irregularly radiating from near its margin.

Within this diaphragm, and between the inner termination of the in-current orifices, are situated the cilia, which are of exceeding tenuity, and of considerable length comparatively.

If the diaphragm be focussed distinctly, and the sponge be alive and active, we shall see, within the area of the circular orifice of the diaphragm, the cilia in rapid motion, many of them being tipped with a small portion of gelatinous matter, or of extraneous fecal matter, and the whole of them are continually oscillating, in a plane parallel to the edge of the diaphragm; while a current of water is as continually being discharged through the orifice of each diaphragm, into the short, angular cavities which line the interior surface of the sponge. And this current is unmistakably apparent, from the frequent discharge of minute molecules of extraneous or fecal matter. I could not detect ciliary motion from the external surface of the sponge, although they were in vigorous action within the cells, when viewed from the opposite surface. Nor were tessellated cells or cilia visible in any other portion of the same sponge.

By this mode of examination the presence and action of the cilia were very clearly demonstrated; but I could not determine their insertion, or the extent of surface covered by them. I therefore decided, if possible, to get a section of the sponge at right angles to its long axis, and endeavour to examine the whole length of the ciliated cell, from its origin, immediately beneath the outer surface of the sponge, to its termination, at the perforated diaphragm near the inner surface; but this was not easily achieved with so delicate and fragile a subject. I found that sections made either with a knife or with the most delicate scissors, had undergone so complete a disrup-

tion of the structures, as to render the whole of these fragile tissues perfectly indistinct; but there was one interesting result from this operation, which was, that from both surfaces of the sponge there were forced out clusters of minute spherical and oval bodies, containing slight traces of granulations within; and along with these masses there appeared, in several cases, cilia similar to those described *in situ* within the diaphragm, and which continued their motion for a considerable period, frequently with so much force as to give a slight motion to the mass of small spherical bodies with which they were connected. From the circumstances I have described I concluded that the only way of proceeding, with any chance of success, would be by carefully pulling the tissues asunder. I then took two parallel holds of the sponge, at right angles to its long axis, with fine spring pliers, and gently pulled it asunder; and, after many trials, I succeeded in getting several of them to divide in a tolerably straight line; and these I cut from the masses, as near the torn edges as possible. I then placed the ring-like sections, as before, in closed cells; and, after many trials, I succeeded in finding some of them with sections of cells which still retained their vital functions, notwithstanding the terrible mutilation to which they had been subjected.

I found the whole length of the cell, from the inner edge of the diaphragm to its termination near the outer surface of the sponge, to be closely studded with tessellated, nucleated, cellular structure, as represented at *c*, fig. 1; and from one or other among these cells I observed several long and very attenuated cilia to spring, and which kept up a rapid action for a considerable period. After a while, as the vital energy of the sponge decreased, their motions became much more languid; and I then observed one in particular, which continued for nearly half an hour to wave gently backward towards the outer surface of the sponge, and then rapidly forward towards the mouth of the diaphragm. In several others the direction of the motion was not so decidedly in the long axis of the cell; but this uncertainty of action might probably have arisen from partial disruption of the tissue.

In the cell thus described there were as many as nine cilia in action together, situated in various parts between the two extremities; but they did not appear to sympathize with each other in their movements. I never succeeded in getting so many of these organs in motion together, in any one cell, in the numerous specimens which

I afterwards examined; but I often had two or three in the remains of cells which I had thus laid open.

I could not discern whether the cilia were based upon the tessellated cells, or whether they sprung from between them; but, from their continual association with the cells when removed from the body of the sponge, I am strongly inclined to the former opinion, and the more so as the tessellated cellular structure does not occur in any other portion of the sponge than that in which the cilia exist and the motions of the currents originate.

The situation and action of the cilia in this species fully explain the powerful and continuous stream that issues from the great ex-current orifice of the sponge, without the necessity for cilia in any other part of the animal.

From the existence of chambers, or cavities, immediately within the in-current orifices of *Halichondria panicea*, and other similarly constructed species, I am strongly inclined to believe that we must look for the cilia in those parts only.

I have frequently taken sections of a large ex-current canal, at right angles to its axis, about the eighth of an inch in depth from the surface of the sponge, while the currents were in action, and have observed that the action continued, in the portion thus separated from the body, ejecting a stream of water from the mouth of the canal, for often half an hour after its separation; and, that no error might arise in the observation, I have always conducted the investigation in a closed cell.

The circulation of the water in the sponge cannot, therefore, be a deeply seated action. In very thin slices from the surface of the same species, with the inner portion towards the eye, I have several times seen the passage of the molecules inward through the in-current pore; but, notwithstanding this, I have never in that species succeeded in detecting the cilia; once only I thought I saw, in one of the cavities immediately within the in-current orifices, the peculiar flickering motion which frequently indicates the presence of those organs when their rapid motion precludes all possibility of seeing them; but I do not attach much value to so slight an amount of evidence of their presence.

## EXPLANATION OF PLATE XIX.

Fig. 1. A view of part of a section of a small specimen of *Grantia compressa* at right angles to the axis of the sponge, exhibiting a longitudinal section of the ciliated cells.

*a*. The exterior surface of the sponge.

*b*. The interior surface.

*c*. The cell in which the cilia *in situ* were observed in action, and in which the cellules on which the cilia are apparently based were in the best state of preservation.

Fig. 2. Represents a portion of the inner surface of a small *Grantia compressa*. The central group of three diaphragms (*a*) exhibits the appearance of the cilia when slowly in motion within the diaphragm, and at *b*, *c*, the same appearance of the cilia, but with extraneous matter adhering to their apices.

Fig. 3. A group of detached tessellated cells, seen by a power of 1120 linear.

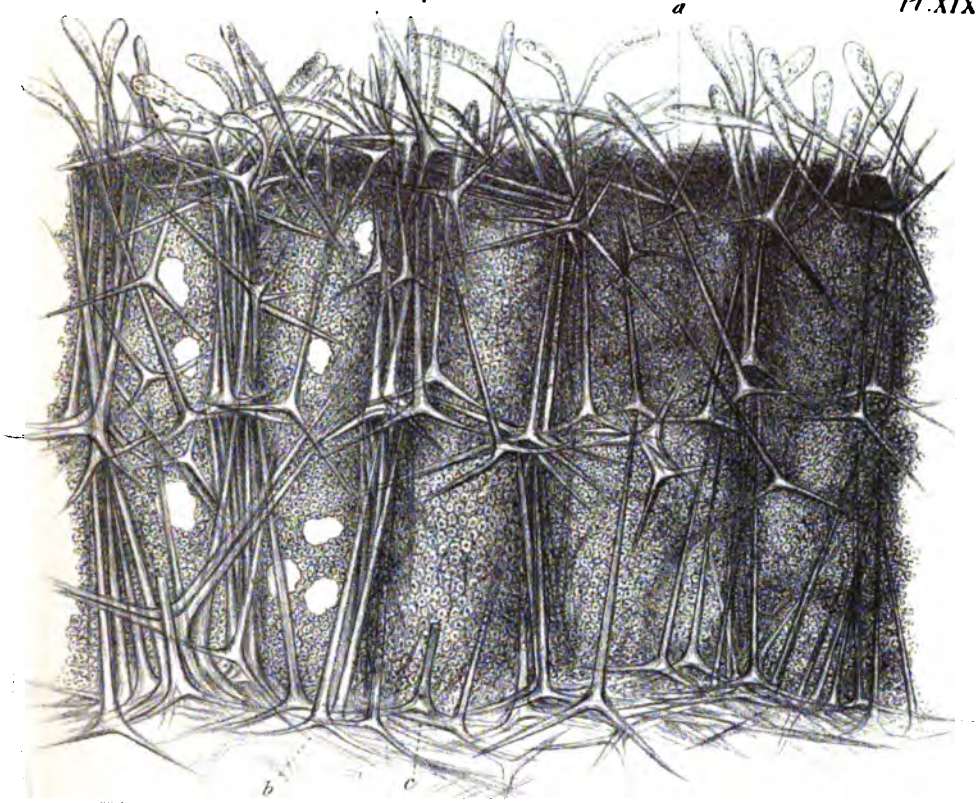
Fig. 4. Detached tessellated cells and cilia.

*a*. Cilium in a state of inaction.

*b*. Cilium in the position when about to strike towards the diaphragm.

Fig. 1~500

PI. XIX.



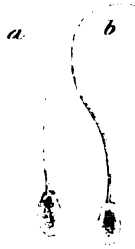




Fig. 4~1120

Fig. 2~500

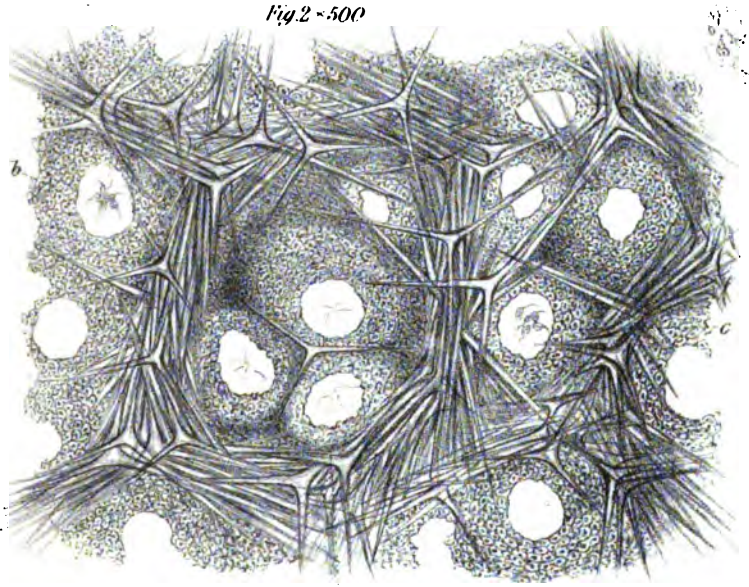



Fig. 3~1120

## XXV. — *On the Notommata parasita* (Ehrenb.), *a Rotiferous Animal inhabiting the Spheres of Volvox globator.* By P. H. Gosse, Esq.

(Read December 11, 1850).

This interesting form was made known in 1835, by Professor Ehrenberg, who has given a brief note of its singular parasitic habits. It first fell under my own notice on the 26th of June, 1850, in water kindly given to me by Alfred Rosling, Esq., of Camberwell, and taken, as I understand, from a reservoir in his grounds. I afterwards obtained it on the 8th of July following, from a little pool near the Railway Station at Leamington, Warwickshire.

No cognizance of this animal is taken by the unassisted eye, for its greatest length (so far as I have observed) is $\frac{1}{100}$ of an inch. The body is somewhat cylindrical, terminating in a blunt point behind, without any foot or toes that I can perceive. When the stomach or ovary is distended, the form is swollen. The gizzard is large and long; not perfectly symmetrical, the point (as is not infrequent in the Hydatineous family) being rather on one side. It contains a long *incus*, which seems to have a forked summit, on which work two apparently simple *mallei*, the one long and nearly straight in the rod, the other shorter and bent inward (see Plate XX. fig. *f*.) The points are capable of being protruded from the mouth (see fig. *e*). By means of the *compressorium*, the forked summit of the *incus* was found to be separable from the rod (as seen at *i*), and to be furnished with a square umbrella, delicately membranous, of two (perhaps four) points. A wide conical alimentary canal, apparently simple, is separated by a long duct from the gizzard, and carries two oval pancreatic glands. The canal tapers to a narrow orifice at the *cloaca*, which is placed at the extremity of the body. The usual occipital sac carries a large eye of a rich crimson hue, set on its dorso-posterior end, like a wart. The *venter* is as usual occupied by the ovary, sometimes containing only clear *nuclei* (fig. *c*); at others, a large opaque granulated egg in process of development, (fig. *e*). A small contractile bladder, whose intermissions are rather longer than usual, is

seated below the ovary. A pair of longitudinal muscles pass from the head to the extremity of the body, one on each side; and one from each side of the gizzard to the same part: there are also seen three or four transversal muscles. (These are all shown at *d*). The head, which is broad and prominent, is surrounded by a wreath of cilia, and a large claviform process projects over the occiput or stands erect. This process, so commonly found in the *Rotifera*, is considered by Prof. Ehrenberg as a respiratory tube; but I have reason to think it is the first rudiment of the antennæ of the higher classes of annulose animals, in which great division I am sure the *Rotifera* find their place. When the head is withdrawn by the contraction of its special longitudinal muscles, the surrounding margin is drawn into puckers. The whole animal is colourless, with the exception of the eye: but the stomach is generally filled with green food; and the opaque developing egg frequently imparts a dark hue to the abdomen, viewed by transmitted light.

The habits of this inconspicuous little *Notommata* are curious, for it is parasitic in the elegant *Volvox globator;* hence Ehrenberg gives it the appropriate designation of "The Pirate." On examining several *Volvoces*, even with a pocket lens, we may frequently detect such as are thus tenanted, by their containing one or more spots differing from the young clusters in form and colour. Each of these spots is found to be a *Notommata*, snugly ensconced within the globe, in the spacious area of which it lives at ease, and swims to and fro, like a gold-fish in a glass vase. We see it for the most part, however, clinging to the inner surface of the circumference, engaged in devouring the green monads with which its gelatinous expanse is studded, or else eating away the embryo clusters. Fig. *a* represents a portion of a *Volvox*, $\frac{1}{50}$ of an inch in diameter, viewed with a power of 220 linear; and *b* is one of the embryo clusters, partially devoured. The action of the protruded jaws of the *Notommata*, as it eagerly nibbles away at the monads, is very energetic; but its progress is not commensurate with its vehemence. I have not been able to see one actually detached and swallowed. Frequently two or more *Notommatæ* are found in the same *Volvox*, and I have seen as many as four, with an egg besides. They do not interfere with each other, but each pursues his own avocation.

It is chiefly the smaller *Volvoces* that contain the parasite, especially those which have the embryos very immature. I have not seen any *loose* in a large *Volvox*, but in embryos almost grown, and nearly ready for escape, I have several times seen a *Notommata*. If

we wonder at this *Rotiferon* obtaining access to the interior of the sphere, we wonder still more at seeing even the young spheres, while yet within the mother-sphere, thus tenanted: especially as the circumference, both of mother and daughter, appears unbroken. On careful examination, however, the parent *Volvox* shows places where the monads are interrupted; and I have thought that I could discover, in each case of a tenanted embryo, that its circumference had a ragged point.

The *Volvox* does not appear to suffer from the depredations of its ungrateful guest; for though half of its young embryos may be devoured, it glides along with as swift and as majestic a course as ever: nor are the vibrations of its *cilia* intermitted, for any floating atoms that lie in its track are hurled away with impetuosity, the moment they come within reach of this living whirlpool.

In some spheres we find eggs with *Notommatæ;* in some, eggs alone. Perhaps the parasite is always hatched in a parent *Volvox*, but the embryo globe is probably entered from without, and the *Notommata* is then expelled with it. The *Notommatæ* frequently eat their way out, and swim at freedom.

Observing one, large with a nearly matured egg, in the globe of a small *Volvox*, I opened the latter with a fine needle, and freed the *Notommata*. This I placed in clear water, and added several *Volvoces* of various ages, taking care that none contained a parasite. I then watched its proccedings, to see if it would enter any one of the globes; but though, in the course of its swift and headlong rotation, it now and then came into contact with a globe, and would arrest its career to play over its surface, and even to nibble at it, it would presently dart away again; not entering one in the lapse of several hours. In the course of this time it deposited its egg loose in the water, which probably it would not have done had I left it to follow the dictates of its instinct. This egg differed greatly in appearance from any that I had as yet seen in the interior of globes; for whereas they were perfectly smooth and translucent, showing the eye, the jaws, and the ciliary motion as these were developed (see fig. *g*), this (see fig. *h*) was opaque, and covered closely with short obtuse prickles. The size of both was nearly the same, measuring $\frac{1}{350}$ by $\frac{1}{440}$ of an inch. Subsequently, however, I found several of the prickly eggs in globes; and in one, both a prickly egg and a smooth one.

In one case I witnessed the evolution of a young *Notommata* from a smooth egg; it exactly resembled the parent. It remained long half hatched, without forsaking the egg, the anterior half of the body

free, rotating, and nibbling actively, while the hind parts remained in the egg-shell; and drawing back from time to time, as if loath to leave its protection. Upwards of an hour elapsed before it was clear from the shell.

I have proved, by actual experiment, of many species, of widely different genera, and have reason to believe of many more, perhaps all, that animals of the class *Rotifera* are not hermaphrodite, but bisexual, the sexes being very distinct from each other in size, form, and structure. Now in every case that I have examined, the male and female eggs differ greatly in appearance, the latter alone displaying the manducatory apparatus in the *fœtus*. The smooth egg I proved to be female; it is possible that the prickly one may be male; not, however, necessarily because it is prickly, for in other genera I have known prickly eggs to produce females. The subject, therefore, and it is an interesting one, lies open for further investigation.

In freedom, the manners of this *Notommata* are lively and energetic: it swims wildly about, often in a zigzag course, turning first to one side, then to the other, as it dashes rapidly along. Sometimes it rotates on its long axis as it goes; and at others it becomes stationary, adhering by the blunt extremity of its body, upon which it turns as on a pivot. It is perpetually contracting and elongating, and throwing its body into angular folds and contortions.

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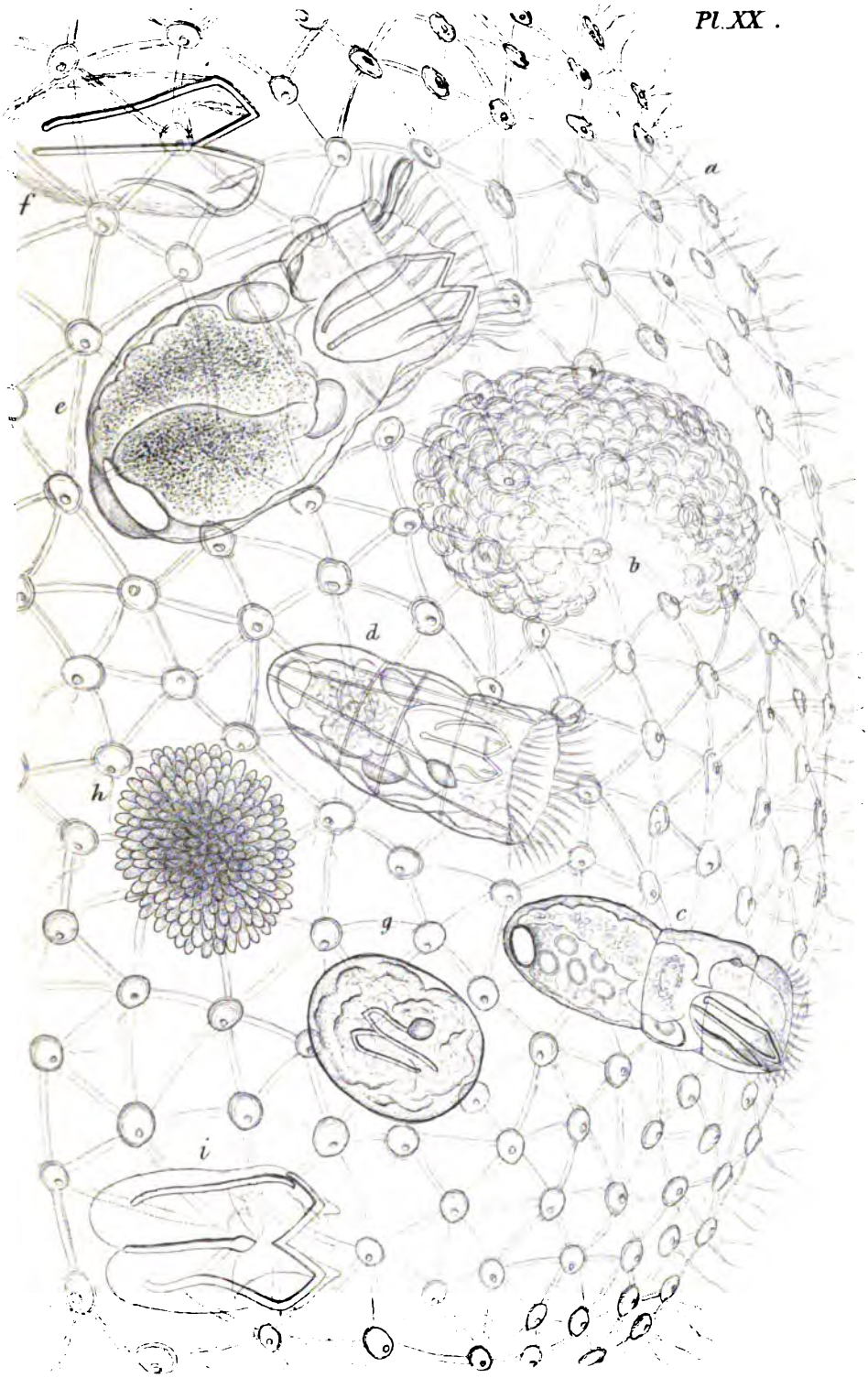
## EXPLANATION OF PLATE XX.

*a*. Part of the sphere of a *Volvox globator*.
*b*. One of its embryo clusters.
*c*, *d*, *e*. *Notommata parasita*, within the sphere.
*f*, *i*. The gizzard of the *Notommata*.
*g*. A smooth egg displaying the embryo.
*h*. A prickly egg.
The whole greatly magnified, but in different degrees.




P.H. Gosse, del. ad. viv. - S.W. Leonard, lith.

Day & Son, Lith.rs to The Queen.

## XXVI.—*On a White Mirror for the Microscope.*

By George C. Handford, Esq.

(Read December 11, 1850).

As the subject of illumination is of so much importance to microscopical observers, I feel that there is scarcely any necessity for apology from me for intruding upon the time of this meeting, in making a few remarks on some of the defects in the means of illumination now in use, and in bringing to your notice a white mirror, which I have made with a view to remedy them.

In viewing objects by lamp-light, which are illuminated by the silvered mirror, there is generally a great glare of reddish-yellow light, which is very injurious to the sight, and the object is in many cases almost obliterated. If it is attempted to lower the flame of the lamp, or to throw off some of the rays by moving the mirror, the definition of the object is interfered with; and the same effect takes place on cutting off the light, by means of the diaphragm, or by altering the quantity of light in any other way.

With the white mirror these defects are, I may say, entirely remedied; and if with a low-power object-glass there should be a little too much light, the flame of the lamp can be lowered, or the mirror altered, without producing the objectionable result before mentioned, and the diaphragm is not needed.

These facts cause me to suppose, that the quality of the light transmitted to the object-glass by means of my mirror is much more pure than by that now in use.

The white mirror consists of a thin, concave glass, three inches in diameter, the back of which is rendered white by means of plaster of Paris, or zinc paint; and it is mounted in brass, and fits over the frame of the silvered mirror, without requiring the latter to be in any way altered.

Mirrors to answer the same purpose could be made of white marble ground concave and polished, or of white opaque glass rendered

concave; and they could also be made of curved and well-glazed porcelain.

Dead white surfaces of plaster of Paris and other materials have been made for the purpose of obtaining a white light; but, whether flat, concave, or convex, they are only useful for very low powers, in consequence of there not being a sufficient quantity of light; and this arises from its being radiated only from such surfaces in all directions, but which I am able, with my mirror, to collect and bring to a focus, along with those rays reflected from the surface of the glass, thereby making use of the whole of the light that it is possible to obtain.

That light is similarly affected by the colour of the surface it is reflected from, I need only mention, as a familiar example, that when a room is lighted only by a dull fire, the colour of the various articles of furniture may be ascertained by that of the light they reflect on the walls and ceiling, and which will show that the reflected light from a white surface is white.

## XXVII.—*On a New Medium for Mounting Fresh or Moist Animal and Vegetable Structures.* By H. Deane, Esq.

(Read March 19, 1851).

As the subject of this paper is one of general interest and utility to every microscopist, and sufficient time has been taken to test its success, I trust I shall need no apology for presenting it to the notice of the Society.

The material to be described is intended to remedy some of the inconveniences of mounting objects in fluid, which are most felt by those who only use that method occasionally, as well as certain defects attending the use of Canada balsam.

The inconveniences alluded to are:—

1st. The necessity of employing, in most cases, some kind of cell to contain the fluid and objects, the cementing or constructing of which causes extra work, and oftentimes prevents the object from being seen under high powers, as the $\frac{1}{8}$th or $\frac{1}{12}$th of an inch.

2nd. The objects not being permanently fixed, and, if consisting of numerous small particles, the slides requiring to be kept in a horizontal position.

3rd. The difficulty of obtaining *any* fluid capable of preserving vegetable and animal preparations in their natural colours, and in other respects without alteration.

4th. The danger of losing a valuable specimen by the evaporation of the fluid caused by the cracking of the cement, arising from any casual violence.

5th. The obliterating effect of Canada balsam on some structures.

It has long been a desideratum to obtain a perfectly transparent substance for mounting objects containing their natural juices, which possesses the same facilities in use as Canada balsam, for the least moisture in the object causes the latter to appear milky and full of bubbles. Various attempts have been made, from time to time, to mount objects in solutions of gum Arabic, isinglass, gelatine, &c.,

but in most instances without success. The chief cause of failure in these substances is, that, when the water or other menstruum necessary to dissolve them has evaporated, the material will occupy less than its original bulk (in some cases less than one-half). The evaporation does not take place uniformly, but acts partially, beginning at the edges; the dry portion is very hard and unyielding, and the shrinking of the remainder of the substance will either fracture or bend the glass cover, or cause vacuities to appear around the object, and will eventually crack in every direction. From the very nature of the substance required, water must form a portion of it, which, when evaporated, will cause the material to occupy less space. The remedy for this would be, a medium possessing such great and permanent elasticity as would neither allow vacuities to appear nor bubbles to increase in size, and which in drying should admit of no portion becoming hard and unyielding, but as the moisture evaporates, allow the cover to settle down uniformly throughout.

My attention was first called to a material possessing this quality by Mr. F. H. Wenham. It consisted of a mixture of French gelatine and a transparent kind of treacle, sold by the sugar-refiners, under the name of "green syrup." This compound, when dry, formed a very elastic material (similar to that of treacle and glue, of which printers' inking-rollers are composed), and several objects have been mounted in it with perfect success; but the colour of this medium was so perceptible as somewhat to limit its utility.

From this I was led to discover a compound possessing the elastic properties of Mr. Wenham's medium combined with perfect transparency. It is composed of the following ingredients:—

1 oz. gelatine
5 oz. water
5 oz. honey
½ oz. rectified spirits of wine
6 drops kreosote.

Soak the gelatine in the water until soft, raise the honey to boiling heat in another vessel, add it to the moist gelatine, and make the whole boiling hot; when it has somewhat cooled, but still perfectly fluid, add the kreosote and spirit, previously mixed together; lastly, filter through fine flannel, or, what is far better, coarse filtering-paper, until perfectly bright. When cold the composition is in the form of a very stiff jelly, which on being slightly warmed runs perfectly fluid.

The quantity of water contained in the above mixture is not absolute, for in some cases it will be necessary that the medium should contain a greater quantity than in others. For example, if it is required that the medium should penetrate into all the pores of an object, with the view of increasing its transparency, the medium must be more diluted. If, on the other hand, it is desirable that objects should contain vacuities, as the tracheal system of insects, the jelly, when cold, must be sufficiently stiff to prevent its being drawn into the tubes, when the water contained in them, or that which has been made to fill them, has left them to combine with the medium during its evaporation.

Not any of the above ingredients are at all likely to injure any objects mounted in the medium. The gelatine has no injurious tendency on either animal or vegetable structures; and honey is remarkable for its preservative properties, as it is well known that leaves, flowers, and fruit may be kept in it for a great length of time without losing their sensible properties to any material extent. The alcohol is added as a solvent of the kreosote, and for diffusing the latter more perfectly through the jelly, and to assist in its preservation, as well as the objects mounted in it; also to defend it from the attacks of mould, insects, &c., for to the latter the compound would be too palatable without some such addition.

This medium is chiefly intended to be used in the same way as Canada balsam, *viz.*, without cells; but in cases where they must be made use of, the cover should not be laid on the cell in the usual way, but be made to fit into it, so that as the medium contracts by evaporation the cover may descend bodily; no cementing of any kind is required; and as it is a matter of indifference about the cells being tight, they may be formed of any porous material, such as cork, pasteboard, &c.*

In mounting objects the usual way, without cells, the chief and most important point to be attended to is to avoid enclosing any air-bubbles; and if the object is dry, such as a section of wood, it should be soaked, or even boiled, for a short time in water, which will drive all the air out of the pores; it is then placed on a piece of paper, in order to drain off the superfluous moisture; and, the medium having been melted, either by placing the bottle in warm water or over a

* Since writing the above, I have found it desirable in most instances to cover the exposed edge of the mounting medium with a little varnish of some kind, to prevent the consequences attending its contraction, which invariably takes place to some extent.

spirit-lamp, a portion of it is dropped on the slide (which should also be previously warmed) by means of a warm glass tube. The object is then taken up, with the needle-point or forceps, and placed in the fluid medium, beginning at one end, and gently lowering it till it is finally adjusted. If any bubbles appear they will rise to the surface, and may be skimmed off with the edge of a pen-knife. If any bubbles are in the vicinity of the object after the cover is on, they may be removed by placing the slide aslant, keeping it warm, with the bubble end uppermost, and they will gradually rise from the object. If the cover is placed on immediately it will sometimes throw the object out of place; therefore it is best to allow the medium to get cool, so as partly to congeal; the cover is then held in the forceps, warmed over the lamp, and placed over the object; and when cold it will remain firmly in its place. If the object is hard and unyielding it will be advisable not to press the cover close down upon it, but to allow a little of the medium to be between the object and cover, which will lessen the risk of damage as the shrinking takes place. It is a convenient way to cut out a piece of the medium, and melt it on the slide; but this increases the risk of bubbles.

Fresh animal or vegetable structures containing their natural juices require little or no preparation before mounting in this substance. Those contained in water, such as Desmidiæ, Crustaceans, &c., may be taken out of their native element, placed on a proper slip of glass previously warmed, the superfluous water removed with a piece of clean cambric or blotting-paper, and then mounted at once, by dropping a little warm medium upon them with the glass tube, and covering with thin glass.

Animalcules mounted in this way do not appear to alter either in colour or dimensions. The latter may be accounted for in this way, —*viz.*, that the contraction of the medium takes place entirely in thickness, and the pressure of the cover prevents any alteration taking place in the object laterally. It is probable that some animalcules may be better shown if some moisture be allowed to remain in the medium, the evaporation of which may be stopped at any stage, by filling around the edge of the cover with gold-size, varnish, or even boiled linseed-oil.

For many delicate objects this has a great advantage over Canada balsam, in not possessing the high refractive power of that substance; and the minute hairs and other parts of insects, that are quite obliterated with the balsam, are beautifully shown in the new medium.

*Note.*—The difficulty of rendering this medium free from impurities, and perfectly transparent, has led to the trial of other substances, for the purpose of obviating this inconvenience; but the result in that respect has not been quite satisfactory. As mounting media, however, the formulæ may be useful, and are as follows:—

*No.* 1.

6 oz. White's patent size
4 oz. honey
A little spirits and kreosote. (Requires filtering).

*No.* 2.

4 fluid ounces of pure glycerine
2 „ distilled water
1 oz. gelatine

Dissolve the gelatine in the water; then add the glycerine, and mix. With care it will do without filtering.

XXVIII. — *Observations upon Oblique Illumination; with a Description of the Author's Sphæro-annular Condenser.* By GEORGE SHADBOLT, Esq.

(Read March 19, 1851).

ALTHOUGH the subject of oblique illumination has been so frequently before the Society of late, I am induced once again to call attention to it, from a conviction that by its aid, if rightly applied in examining the structure of a certain class of bodies, much valuable information may be acquired, otherwise very difficult, if not impossible, of attainment.

Having devoted much time and consideration to this mode of manipulation, I purpose defining the principles which I conceive should be kept in view, in order to obtain the greatest amount of advantage derivable from it.

This subject may be best considered under two distinct heads, *viz.*, illumination by oblique light on one side only; and illumination by opposing rays, so as to obviate any shadow.

The former mode has been long familiar to microscopists; the latter having been but recently suggested, and carried out by Mr. Wenham in his valuable parabolic condenser.

As regards oblique illumination *in one direction*, the cleverly constructed prism of M. Nachet (a description of which I had the honour of offering on a former occasion) affords an infinitely superior mode of application to the old method of turning the mirror on one side, besides some other advantages needless to recapitulate at present.

But whatever may be the mode adopted for condensing the light *on one side* of an object, the chief advantage obtained is a certain amount of shadow resulting from any variations of surface, which renders such variations more perceptible by the contrast thus afforded. A fact tending to support this view is, that in certain objects (those, for instance, which have minute ridges on the surface) the details become visible *only* when the light is caused to fall at right angles, or nearly so, to the course of the *striæ*.

If the light be caused to fall with sufficient obliquity, what is known as the "black field illumination" is produced; but in this case, the shadow resulting from the light in one direction only is a positive detriment to distinct vision, and generally renders the object confused and deceptive in appearance.

In order to obviate this objectionable shadow, as well as to procure a more brilliant illumination, the parabolic condenser was projected by Mr. Wenham, to whom alone belongs the credit of having suggested the use of oblique illumination *in every azimuth*, so as to produce a black field; and for a detailed description of whose apparatus I must refer to his paper, already published in the 'Transactions' of this Society.

The great advantage of a black field illumination, under the conditions above described (that is, free from the objectionable shadow), becomes eminently apparent, for as the only visible rays proceed directly from the object under examination, and the eye is not fatigued or the attention distracted by any extraneous light, the effect produced is almost tantamount to an enlargement of the aperture of the objective.

Having carefully considered this happy idea, so ingeniously brought to bear in aiding the researches of the microscopist, it occurred to me that it might be possible to carry out the principle still further than had as yet been done, and at the same time to obtain a better reflecting surface, and also greater facility in the manufacture of the necessary apparatus, by making it of glass instead of metal. I was at once met by a difficulty in testing this notion, owing to the existing necessity, in polishing glass, of *a double motion*, such as is effected in lenses by changing the axis. Moreover, to produce a paraboloid correct in figure, is by no means a very easy task: I consequently devised the *annular condenser*, a hasty description of which I gave in June of last year. Since that time I have endeavoured to simplify the arrangement by making use of spherical surfaces, having *all* their centres in the axis of the instrument, but here again I was baffled by the great amount of aberration.

I have however at length succeeded in devising an arrangement of spherical curves, *one centre only* being eccentric, which fully answers my expectations, and is easy of manufacture. The spherical aberration, although not quite destroyed, is but trifling, and does not materially impair the efficacy of the instrument, which I have named the *sphæro-annular condenser*.

My thanks are justly due to Messrs. Powell and Lealand, and to Messrs. Smith and Beck, for the accuracy with which they have constructed the apparatus according to the drawings I furnished them with.

When this species of illumination is adopted, whether by means of the parabolic or my own condenser, the aperture must of necessity be *greater* than that of the object-glass, in order to produce the black field, the rays of light being thus prevented from entering the objective, unless previously affected by the interposition of an object; and I find in practice a direct corroboration of a point which had previously occurred to me in theory, *viz.*, that the best effect is produced when the aperture of the condenser is but *a few degrees* greater than that of the object-glass with which it is intended to be used. This is a fact of which I have no doubt whatever. The explanation I take to be as follows: — When viewing an opaque object, the light thrown upon it is partly absorbed and partly reflected, or, as some would call it, *radiated*, that is, reflected *in all directions*, and not as a polished surface reflects: provided it be understood what is meant by this term *radiated;* which is a convenient one to designate the kind of reflection indicated. It is therefore by this radiated light that the eye is stimulated in viewing an opaque object; and the more vertically the light is thrown, the better will be the illumination, owing to the fact, that *the same quantity of rays* have a larger surface to illuminate when thrown obliquely than when falling vertically, the light being more and more diluted as the obliquity increases.

Now with the black field illumination, although the light is transmitted through the object, in this case also a portion of it is absorbed, and (unless the surfaces of a homogeneous structure be parallel and polished) the remainder is *refracted radially*, so that, in point of fact, it differs but little, if at all, from what we have agreed to call radiant light in an opaque object; the one being reflected in all directions, the other refracted in the same way.

Although a certain amount of obliquity in the incident ray is necessary to produce the dark field, yet in order to obviate any needless dilution of the light, it is highly desirable that the obliquity should not exceed what is absolutely requisite, particularly as those objects which exert the least amount of force in altering the direction of the rays, are precisely those in which the extra assistance to definition afforded by this species of illumination is most required, and consequently the *directive* force should be tasked as little as possible.

Under these circumstances, it is highly desirable that the condenser should be constructed specially with reference to the *aperture* of the object-glass with which it is intended to operate; and for a reason to be given immediately, it will be seen that cutting off some of the rays, in order to make a condenser work with objectives of very much larger aperture, although quite practicable, and even generally in use with the parabolic condenser, is not nearly so advantageous as the use of a separate condenser for every object-glass. This observation applies equally to the parabolic as to the sphæro-annular condenser. The absolute quantity of light capable of being condensed on any object, is limited by the *diameter* of the condenser; and the area of circles being proportionate directly as the *squares* of their diameters, it follows that any reduction of the effective reflecting portion *near the circumference*, diminishes the quantity of light in a much greater degree than would be the case from a corresponding reduction of the reflecting portion nearer the centre: but if a condenser be constructed for a small aperture, in order to make it act with an object-glass of large aperture, it is the circumferential rays which must be cut off, and the amount of light is thus materially reduced, with a power requiring on the contrary more. Again, if a condenser be constructed for a large aperture, and it be used with an objective of much smaller aperture, there is no means of reducing the obliquity of the light, and consequently of satisfying the condition that the aperture of the condenser should only be a few degrees differing from that of the objective; and this I find practically a much greater inconvenience than the defect previously adverted to.

As the cost of the glass part of the condensers is very moderate, I therefore strongly advocate the use of a separate condenser for every object-glass, of high power at least.

I have now to explain the mode of designing the sphæro-annular condenser for any given aperture, which is most readily accomplished, and with sufficient accuracy for all practical purposes, by means of enlarged diagrams.

Having drawn a perpendicular line, *d b* (fig. 1. page 158), make the angles *x d b*, *y d b*, each equal to half the given aperture; and draw the line *x y* at right angles to *d b*, so that it is equal to the intended diameter of the condenser. Draw *y o* parallel to *d b*, and bisect the angle *d y o* by the line *c y*. Draw a line through the point *d*, and another, *n*, at such distance below as is fully equal to the thickness of a glass slider, or something more, and let both be parallel to *x y*; then with the centre *d*, and some distance, *d m*, beyond the lines *n*

and *d y*, draw an arc cutting the perpendicular *d b* in *z*; then through the point *z* draw the line *c m*, in such a way that it shall equal *c y*, and with *c* as a centre and distance *c y*, draw the arc *y m*, which will form the side of the condenser.

All the requisite data are now ascertained, *d* being the focus and centre of the concavity, *d b* the longitudinal distance of the centres of convexity and concavity, and *b c* the amount of excentricity from the axis.

In order to avoid taking off any of the reflective power of the convex sides by the brass setting, it is as well to remove the base line, *x y*, some little distance lower, to *s s*, and leave the intervening portions of the sides, *x s*, *y s*, unpolished. The side *y m*, being the arc of a circle, allows the axis of motion to be changed while the glass is undergoing the process of polishing. The space *l l* (fig. 2) is filled with some opaque substance, to intercept any central rays.

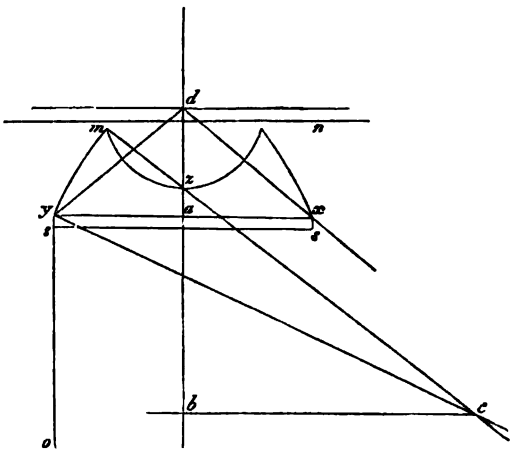



Fig. 1.

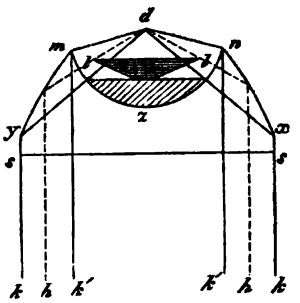



Fig. 2.

The action of the instrument is as follows:—The light is reflected from the plane side of the mirror in parallel rays, *k k*, and falling perpendicularly on the base, *s s* (fig. 2), suffers no refraction, but passes on to the convex surface, *y m*, &c., where, as the angle of incidence is in no part *less* than 45°, it is totally reflected and comes to a focus at *d*, uninterrupted on emerging from the glass, as each ray falls perpendicularly on the concave surface, *m z*.

It will at once be evident that the radius of the concave surface is immaterial, *provided* the centre be truly situated at the point *d*, (a

matter of no difficulty whatever); and provided there be sufficient space to allow the interposition of the glass on which an object is mounted.

In making observations with the assistance of the parabolic or of the sphæro-annular condenser, and an object-glass of large aperture, the correct adjustment for thickness of the glass covering the object, a point at all times of importance to anything like fine definition, is doubly necessary with this mode of illumination.

Either of the above-named instruments may be adapted to the illumination of *opaque objects* under high powers, by using a plane silver reflecting surface, slipped over the front of the objective, in the same way as a Lieberkuhn is commonly applied, and raising the condenser under the object, so as to get the focus correctly adjusted. This, however, I consider of less importance, on account of the ordinary mode of viewing objects illuminated by these condensers possessing most, if not all the advantages of an examination of bodies as opaque. *

Those who have only occasionally glanced casually at an object thus illuminated, cannot form any just notion of the full merit of Mr. Wenham's suggestion, which, however, becomes more and more apparent by familiarity with it.

The various attempts which have been made to produce the same effect by different means, show more strongly than words can do, the fact that there is *something* worth an endeavour to attain, and I can, from practical experience, assert most positively that a very valuable adjunct to our means of investigation has been placed at our disposal; and this I can do with the less hesitation, as, although a promoter, I am not the originator of it, the whole merit being due in a quarter which I have already indicated.

In conclusion, I have only to remark, in order to prevent being misunderstood, that I do not consider it is by superseding, so much as by adding to, our present means of acquiring information, that we may hope to make steps in advance.

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* Since writing the above paragraph, I have been informed by Mr. Brook that this is precisely the same mode of viewing an opaque object, in principle at least, which he had previously made use of.

## XXIX. — *Descriptions of three Species of Marine Zoophytes.* By Arthur H. Hassall, M.D., and John Coppin, Esq., M.A.

(Read April 16, 1851).

### Genus Coppinia.

Char.—*Polypidom* parasitic, massive, hirsute; polype-cells arising at irregular intervals from the angles of junction of a cellular basis, the cells or apertures (*sporangia*) forming which are, when perfect, provided with an *operculum* or lid, perforated by a small tubular orifice.

"*Polype* hydraoidal, vivid green, stretching much beyond the circular orifice of the cell, and furnished with 8 muricate tentacula."—*Dalyell.*

*Propagation* "through the medium of a *planula*, which, instead of being generated as in the hydraoidal *Sertulariæ*, within a pod or vesicle, is formed within the cells (*sporangia*) of the cellular matrix."—*Dalyell.*

Coppinia, Hassall, Zoologist, No. 69, p. 2223. Gray, List of British Radiated Animals, p. 144.

*Conchella*, Gray, loc. cit. p. 88, 144.

### *Coppinia mirabilis.*

Char.—Polype-cells tubular, elongated, often curved; basal cells or sporangia angular, united together so as to form a cellular stratum, presenting a honey-combed appearance; *sporangia*, when mature and perfect, provided with *opercula*.

Plate XXI., figures 1 and 2.

*Campanularia intertexta*, Couch, Corn. Fauna, iii. 41, t. 11, fig. 3. Johnston, Hist. Brit. Zooph. ed. 2, p. 109.

*Sertularia arcta*, Dalyell, Anim. Scotl. 224, t. 42.

*Coppinia mirabilis*, Hassall, Zool. No. 69, p. 2223. Gray, loc. cit. p. 144.

*Conchella intertexta*, Gray, loc. cit. p. 88.

Hab. Coast of Dublin, 1842, on *Sertulariæ*, principally *S. abietina*, *A. H. Hassall.* Coast of Cornwall, *Couch.* Ramsgate, *J. Coppin, Esq.* Orkneys, *Prof. E. Forbes.*

It is somewhat singular that this curiously formed zoophyte should have been so long overlooked, since it is by no means uncommon. One of its principal peculiarities consists in the circumstance that the vesicles containing the ova are not, as they usually are, scattered at intervals over the polypidom, but are united together so as to form a cellular matrix.

The entire polypidom, when perfect, presents to the naked eye the characters of a minute sponge, with which it has doubtless been frequently confounded by observers: specimens, when imperfect, that is, when the cells are short, and the cellular matrix is either not developed, or has been destroyed, bear much resemblance to Cornularia rugosa, for which also, on a superficial examination, it might be mistaken; indeed, there is much reason to suppose that it is closely allied to this species, near which, in a natural arrangement, it will probably find its proper station.

There is but little doubt that the *Campanularia intertexta* of Couch is identical with *Coppinia mirabilis*, notwithstanding that the characters given of that species agree in scarcely any one particular with the correct description of the zoophyte under consideration. The specific name of *intertexta* has little or no application to this species, and has therefore been omitted.

The definition given by Mr. Couch of *Campanularia intertexta* is as follows: — "*Texture* spongy, composed of single tubular fibres, very much interwoven with each other, not ringed: *cells* campanulate, apertures even."

The first accurate description of this remarkable production was that of Sir John Dalyell, who has published a very correct account of both the polype and the polypidom, under the name of *Sertularia arcta*, (the Crowded Sertularia). The figures illustrating the structure of the polypidom, by no means do justice to its singular conformation. The drawings which accompany this communication are very accurate representations of two conditions of the polypidom, and have been drawn with great care by the aid of the camera lucida.

The specific name next in chronological order after *intertexta* is that of Sir John Dalyell, and in strict propriety it ought to have been retained; it may be remarked, however, that the characters of the genus *Coppinia*, as well as its generic and specific names, were deter-

mined upon, previous to my acquaintance with the description of Sir John Dalyell, and also that the remarkable organization of this zoophyte seems to call for some significant, appropriate and striking specific appellation.

The genus *Conchella* (a little shell?) of Mr. Gray, is identical with this genus, an identity apparently not perceived by Mr. Gray himself, since that gentleman gives the characters of *Coppinia* as taken from the MS. of Dr. Hassall, distinct from *Conchella*.

The genus *Coppinia* was first defined in the 'Zoologist,' No. 69, p. 2223, prior to the publication of the 'List of British Radiate Animals' contained in the British Museum.

*Sertularia gracilis.*

Char.—*Polypidom* slender, cells opposite, tubular, everted; apertures oblique, somewhat mucronated, having an average diameter of about the $\frac{1}{3}\frac{1}{6}$th of an inch; vesicles sessile, obovate, with circular, smooth, terminal perforations, averaging the $\frac{1}{1}\frac{1}{3}\frac{1}{6}$th of an inch in diameter.

*Sertularia gracilis*, Hassall, Ann. Nat. Hist. 1848, (cover); Zool. No. 69, p. 2223. Gray, List of British Radiate Animals, p. 150.

Hab. "Mr. Such has sent me a very pretty and delicate variety (of *S. pumila*), which he finds on the coasts of Cornwall and Norfolk." — *Johnst. Brit. Zooph. ed.* 2, *p.* 67. Brighton and Ramsgate, *Mr. Coppin.*

Plate XXI., figure 3.

This, one of the most slender and delicate of the *Sertulariæ*, would appear to be not uncommon, but to have been hitherto always regarded as a variety of *Sertularia pumila;* to that species the zoophyte under consideration does indeed bear considerable resemblance, but differs from it in the very much smaller size of all its parts, and in the exact form of the vesicles, — differences so considerable, that not the smallest doubt can be entertained respecting its specific distinctness.

*Sertularia gracilis* agrees with *S. pumila* in its habit, it generally growing upon *Fuci*, especially *Fucus serratus*, and being therefore an inhabitant of shallow water; in its height, it rarely attaining an inch; in being sparingly branched; and in its opposite cells: it differs from that species however in its more slender polypidom (a difference of size amounting fully to one-half, and which is very obvious even to the naked eye), and in the form of the ovarian vesicles, which

are more pyriform or fig-shaped, and furnished with much smaller apertures than are those of *S. pumila*. In *Sertularia gracilis* the diameter of the polype-cell is only the $\frac{1}{115}$th of an inch, while in *S. pumila* it is the $\frac{1}{75}$th; again, in the former species, the breadth of the opening of the vesicle is but the $\frac{1}{125}$th of an inch, while in the latter it is as much as the $\frac{1}{3}$rd. The latter difference is particularly constant, and, when taken in connexion with the great disparity in the size of the two zoophytes, is quite sufficient to establish the claim of *Sertularia gracilis* to rank as a distinct species.

The differences indicated in the above description, are admirably shown in the figures which illustrate this communication, and which are drawn by means of the camera to the same scale.*

### *Campanularia serpens.*

Char.—*Polypidom* encrusting, spreading; cells small, sessile, often curved, with an even patulous rim; root-like fibres obscure, firmly attached to the object (often a *Sertularia*) upon which the species is developed, and incapable of being detached and exhibited in a separate form.

*Campanularia serpens*, Hassall, Zool. No. 69, p. 2223.

*Capsularia serpens*, Gray, List of British Radiate Animals, p. 151.

Hab. Coast of Dublin, 1842, *Hassall*, on *Sertularia abietina*.

Plate XXI., figure 4.

This zoophyte bears much resemblance to *Campanularia dumosa*, with which, as it appears to be by no means uncommon, it has probably been frequently confounded. It differs, however, from that species, in the smaller size of the cells; in that these are invariably sessile; and, above all, in the absence of distinct root-like fibres, capable of being detached, and separately exhibited.

* One only of these figures is given, that of *Sertularia gracilis*.

## EXPLANATION OF PLATE XXI.

Fig. 1. Polypidom of *Coppinia mirabilis*, in its perfect condition, showing the polype-cells, matrix, and opercula.

Fig. 2. A variety in the polypidom of *Coppinia mirabilis*, in which the polype-cells are much elongated and twisted, and the matrix less regular and perfect.

Fig. 3. Polypidom and overgrown vesicles of *Sertularia gracilis*.

Fig. 4. Polypidom of *Campanularia serpens*, parasitic on *Sertularia abietina*.

Fig. 1.

Pl. XXI.

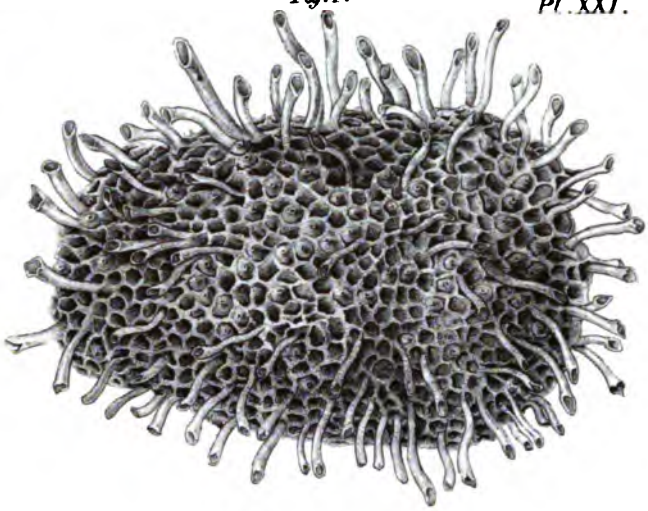
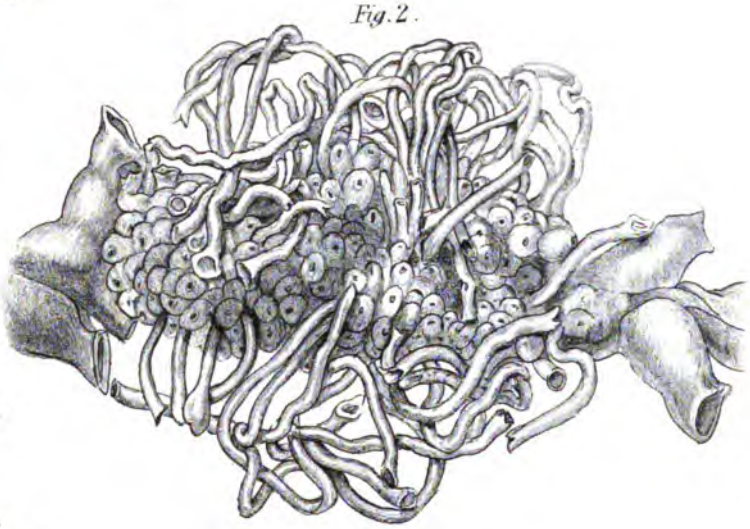


Fig. 3.

Fig. 2.



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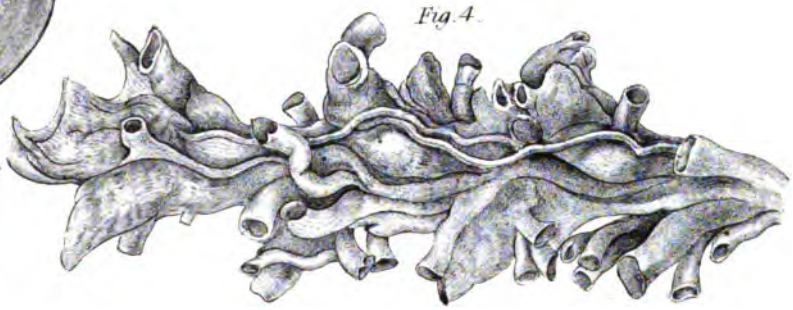

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## XXX.—*On the Sporangia of some of the Filamentous Fresh-water Algæ.* By George Shadbolt, Esq.

(Read May 21, 1851).

In pools and ditches in open places may generally be seen, either floating on the surface or nearly submerged, a mass of slimy green matter, which on slight examination proves to be composed of thread-like filaments; and on closer inspection the filaments are found to consist of cells, more or less elongated and cylindrical in form, and united to each other by their ends. Although by the unassisted eye most of the species of the filamentous *Algæ* are scarcely distinguishable from one another, there are many genera contained in the order; and in the genus *Zygnema* the species are extremely numerous.

Those who are totally unacquainted with this department of botany will do well to refer to Hassall's 'British Fresh-water Algæ,' a work in which much information is given; and, though some of the *opinions* there expressed have since proved erroneous, it must be remembered that when the work first appeared comparatively little had been done in this branch of science. The facts I am about to detail have been ascertained by actual observation; and I had believed them hitherto entirely unknown, until corrected on this point by Mr. Bowerbank, who, however, informs me that he is not aware of their ever having been published.

In Mr. Ralfs' beautiful work on the British *Desmidieæ*, with which most microscopists are doubtless familiar, a very particular and lucid account is given of the conjugation of two cells, and the consequent production of a sporangium resulting from the absorption of the endochrome contained within them. A similar effect takes place with most, nay, I believe with all, of the filamentous *Algæ;* but in this case the union takes place sometimes between cells of the same filament, and sometimes between those of different filaments. In some instances the union of the cells is effected by the intervention of little tubular passages, thrown out for that special purpose, and in others directly, without the intervention of such tubes.

In Mr. Hassall's work, all the sporangia which he has figured as resulting from the conjugation of the filamentous *Algæ* are more or less of a spheroidal or ellipsoidal form, with the exception of that of the genus *Staurocarpus*, which is somewhat cubical. That such forms do result is perfectly true; but I have positive evidence that in two species of *Zygnema* ascertained, and another species in the family not ascertained, the forms figured are *only the sporangia in a transition state*, and that they eventually become *stellate*, and very similar to the sporangia of the *Desmidieæ*, and to the so-called *Xanthidia* found in the flint, with which I entertain very little doubt they will at some time prove identical.

In the middle of the month of April, in the current year, I first saw a single specimen of the sporangium, in its *stellate form*, of *Zygnema quadratum*, to which my attention was directed by Mr. Hodgson, while examining some specimens we had just previously been collecting in Hainault Forest. I imagined it was a sporangium of one of the *Desmidieæ*, and sought amongst the mass of filaments and ellipsoidal fruit (which latter was very abundant), endeavouring to find out to which of the *Desmidieæ* it appertained, but without success; neither did I then discover any more similar forms. Fortunately, however, I preserved the specimen, and some few days afterwards, when again seeking amongst the filaments, observed six or eight of the stellate bodies, and was not a little surprised to find one specimen *within the walls* of a filament.

This led me to suspect that it might possibly be a more perfect form of the ellipsoidal sporangium; and within a few days I had the satisfaction of verifying the fact more distinctly; for, having isolated the mass of *Zygnema quadratum*, and placed it in water exposed to the sun's rays, I examined it carefully, day by day, and ascertained not only that the number of stellate forms rapidly increased, but obtained them in various stages *within* the frond, *the mass of green matter being sometimes entirely and sometimes only partially converted*, but with sporangia in the earlier stage (that is, of an ellipsoidal figure), *on either side of it, in the same frond* (Plate XXII. fig. 1, *a, b, d, e*). So great was the increase of the number of the perfect sporangia during the lapse of the few days, that, whereas in a search of some hours I could not detect more than eight individuals when I first sought for them, in about ten days afterwards I found no less than twenty-six in a single slide which I mounted, consisting only of a small quantity, that could be looked all over in five minutes; and in some cases the spines were bifurcated. (Plate XXII. fig. 1, *c, f, g*).

I would remark that the *Zygnema quadratum* is a species with the ends of the cells inverted, and in which conjugation takes place between contiguous cells of the same filament.

In the *Zygnema varians* the conjugation, on the contrary, occurs between the cells of different filaments, and the ends of the cells are *not* inverted. In this species, also, I have found the stellate sporangia, though as yet not quite so plentifully as in the preceding. There is a slight difference in the appearance of the two sporangia, the spines being more acute and lengthened in the latter; but the distinction is not very marked to a casual observer. I have also a few specimens of a stellate sporangium differing materially from the two preceding, which I conceive to belong to a species of *Tyndaridea* (though this is little more than conjecture), in which the spines are infinitely more numerous and delicate, and bear a close resemblance to the figure of what is called *Xanthidium hirsutum* in the first volume of the 'Transactions' of this Society. (Plate XXII. fig. 3).

I have found the new gelatinous medium recently suggested by Messrs. Wenham and Deane extremely convenient for mounting the sporangia as permanent objects, though it does not answer for mounting the *Algæ* before conjugation; and I purpose depositing in the cabinet of the Society specimens thus prepared of the objects I have so inadequately attempted to describe.

It is not very surprising that these interesting bodies should have been pretty generally overlooked, when we remember that as soon as the union of the conjugating cells has been completed the *Algæ* generally sink to the bottom of the water; consequently, if any one should feel sufficiently attracted to the subject to enter into any more lengthened investigations than I have been able to accomplish, I would by all means recommend him to secure such specimens as he may find in fruit, in any stage, and, having placed them in glass jars, expose them to the influence of the sun, but in such a way that they can, by falling to the bottom, be protected from it.

In conclusion, I would remark, that the gradual change of form in the sporangia of the filamentous *Algæ* is precisely analogous to the progressive increase of the spines of many of those belonging to the allied *Desmidieæ;* and, with regard to the designation of these bodies as sporangia, I have simply adopted that made use of by those best acquainted with aquatic botany, without attempting, from any observations now made, to adduce any reason for deciding whether they are truly sporangia or only spores.

a gentleman who has had considerable experience in delineating objects of this class, having executed for his own portfolio many faithful representations of *Algæ* and *Diatomaceæ*.

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## EXPLANATION OF PLATE XXII.

Fig. 1. *Zygnema quadratum.* — *a*, sporangium in the vesicular state; *b c*, sporangia in the stellate form, all within the original cells; *d*, *e*, *f*, *g*, stellate sporangia, in the two latter some of the spines are bifurcated.

Fig. 2. *Zygnema varians.* — *a*, *a*, sporangia in the vesicular state; *b*, *b*, stellate sporangia in the original cells, which are now much inflated.

Fig. 3. Sporangium presumed to belong to a species of *Tyndaridea*, having been found mixed with filaments of that *Alga*.

Fig. 4. *Lyngbya floccosa.* — *a*, Sporangia within the frond; *b*, sporangia before the formation of the spines; *c*, with spines at an early stage; *d*, with spines fully developed; *e*, same as the last, but more highly magnified.

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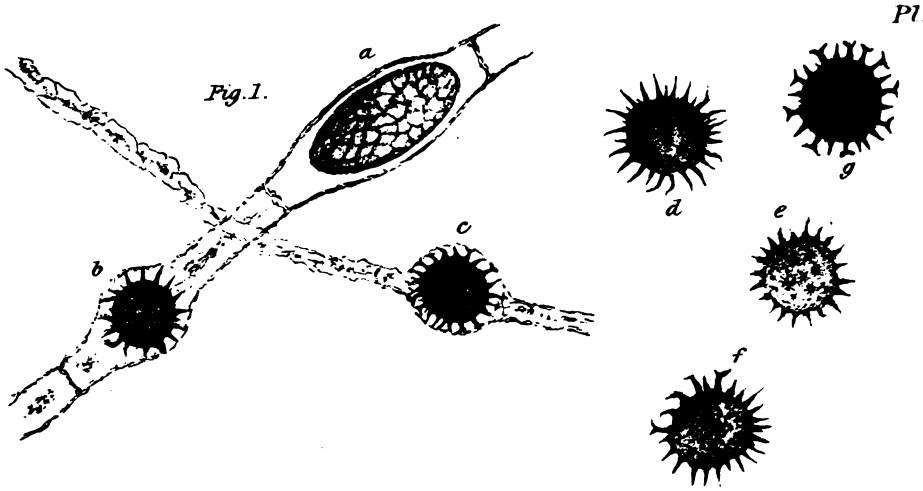


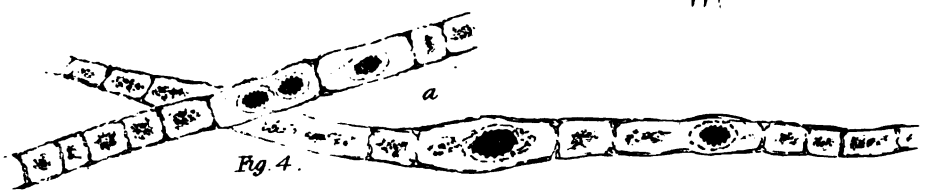


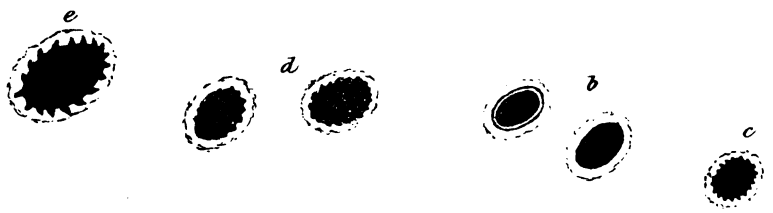


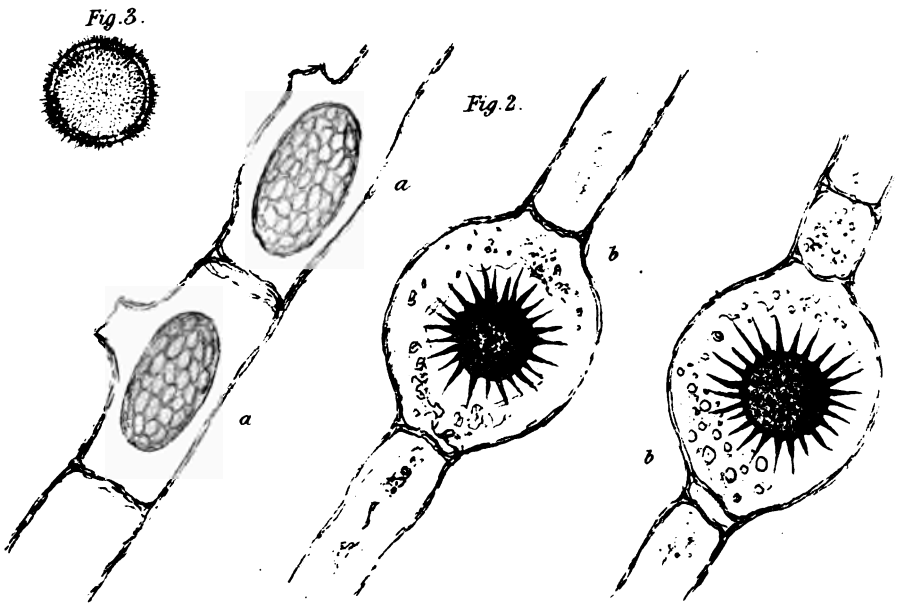


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